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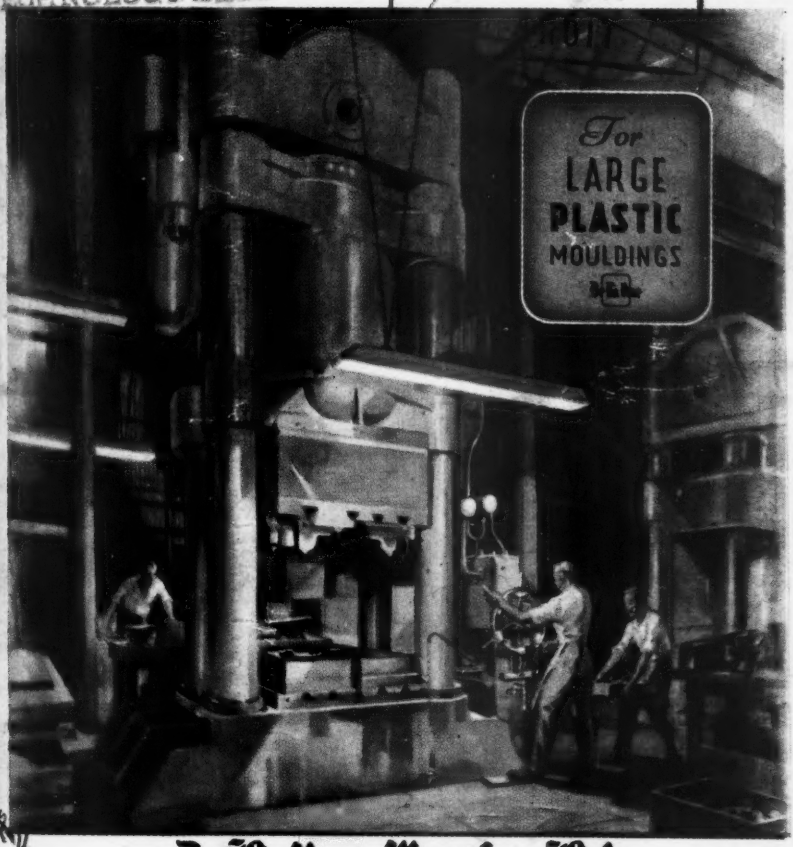
Plastics

DEALING WITH THE MANUFACTURE, USES AND POTENTIALITIES OF PLASTIC MATERIALS

TECHNOLOGY DEPT. MAR 7 19..



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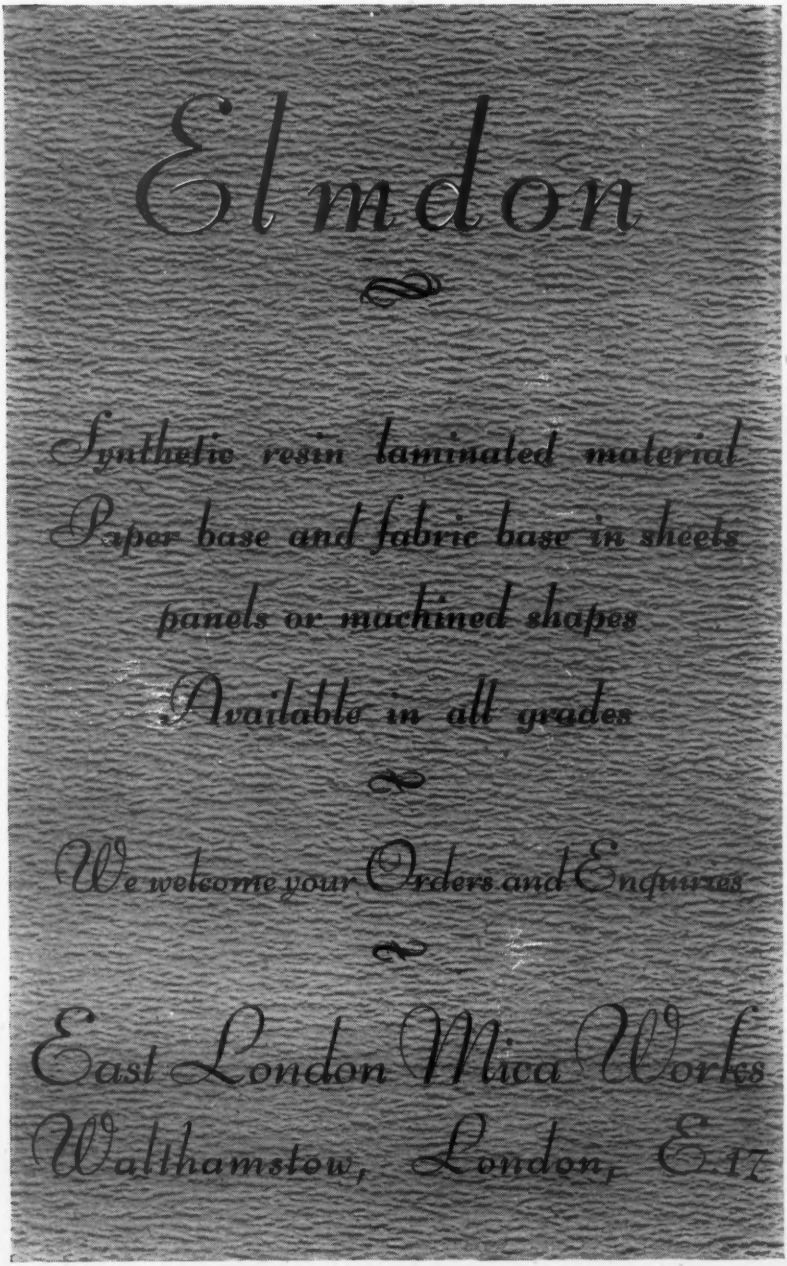
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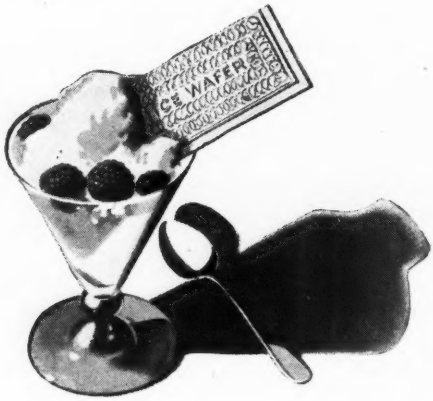

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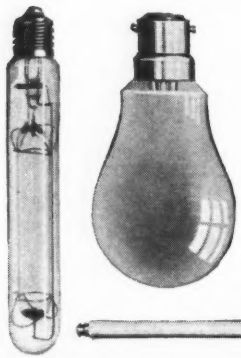

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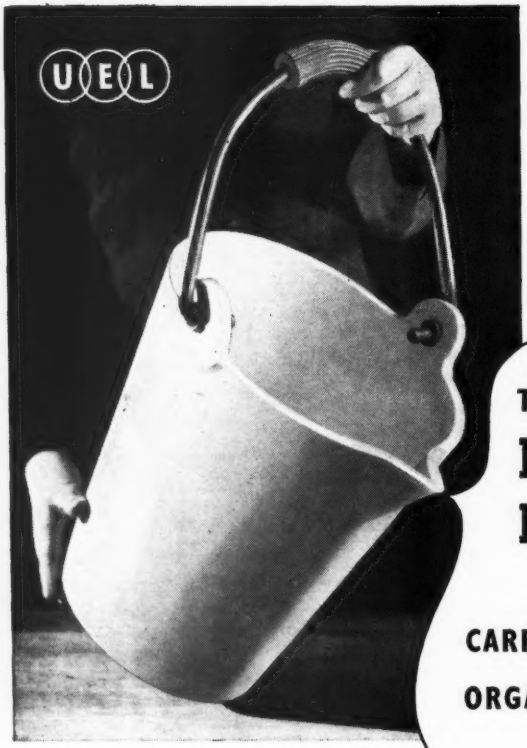

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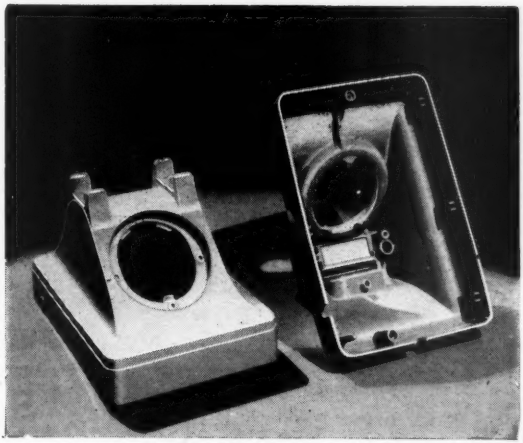

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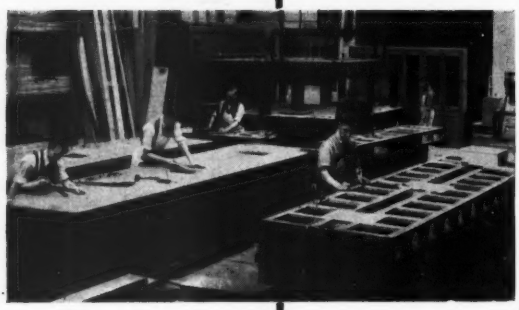

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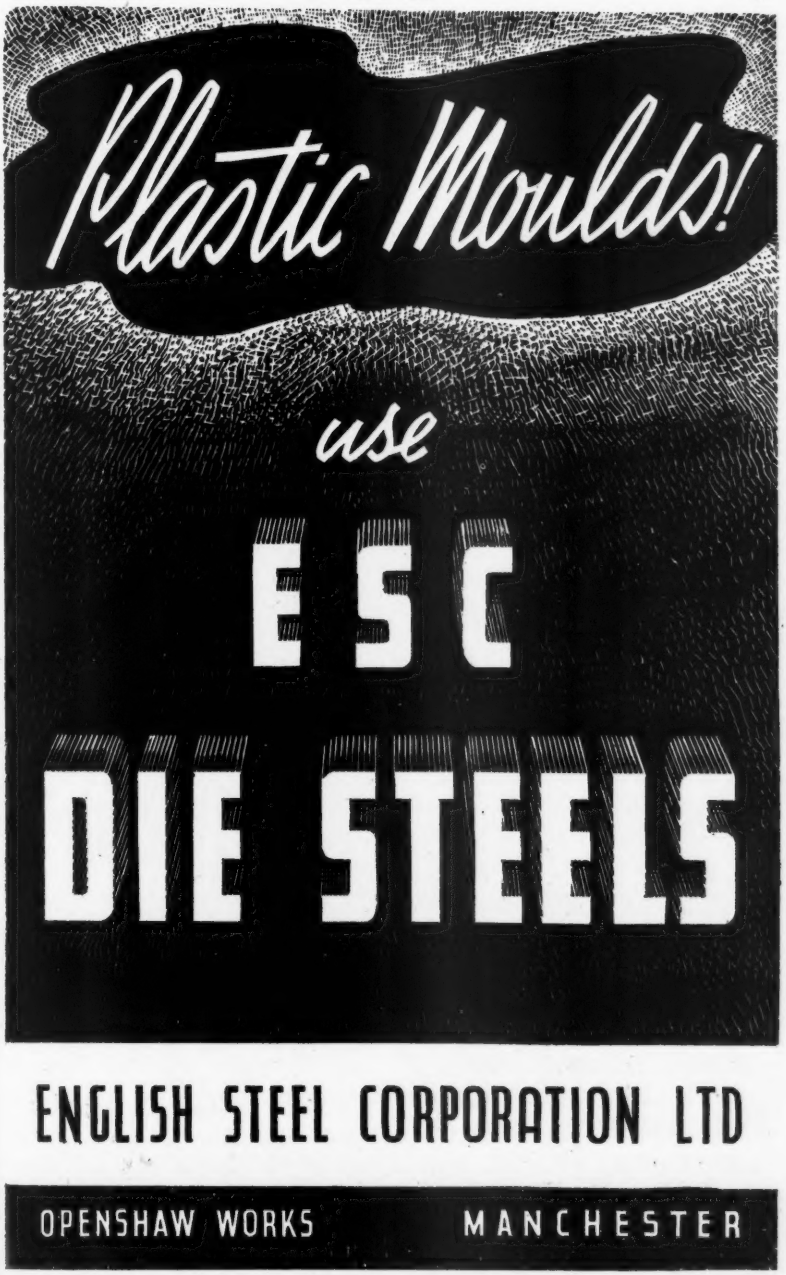
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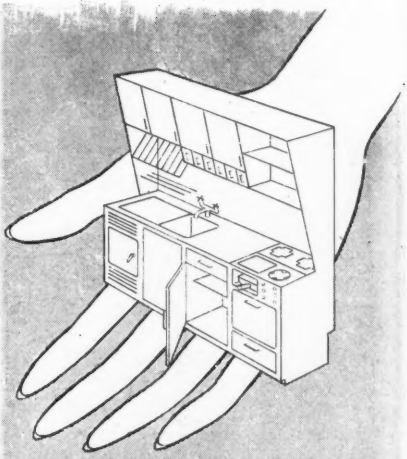

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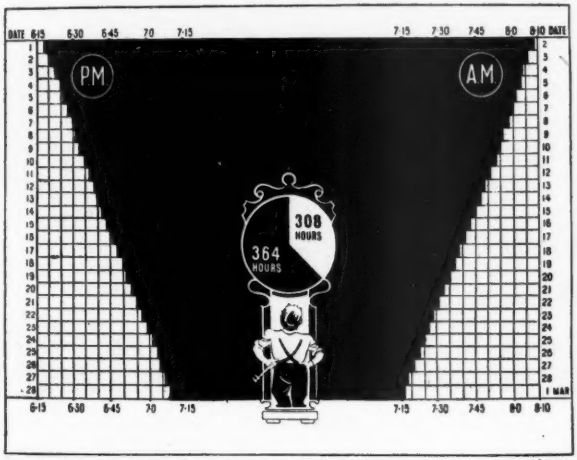
The Turn of the Tide

DIM-OUT CHART FOR FEBRUARY



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**Times shown are those for the London area.*

It is in February that already we feel the approach of spring. Better weather is ahead, the dark days of winter are receding. In the industrial field, February heralds the narrowing of the dim-out chart, but during the shortest month, however, blinds must be drawn for over 364 hours.

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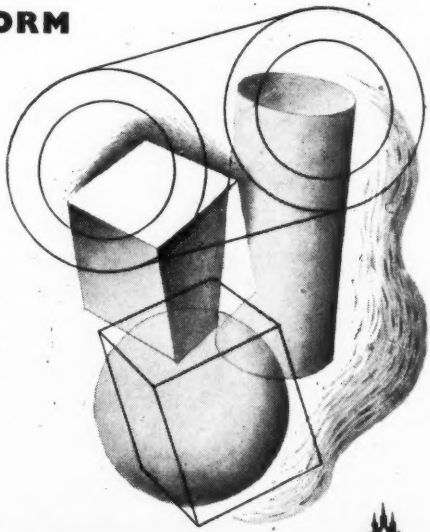

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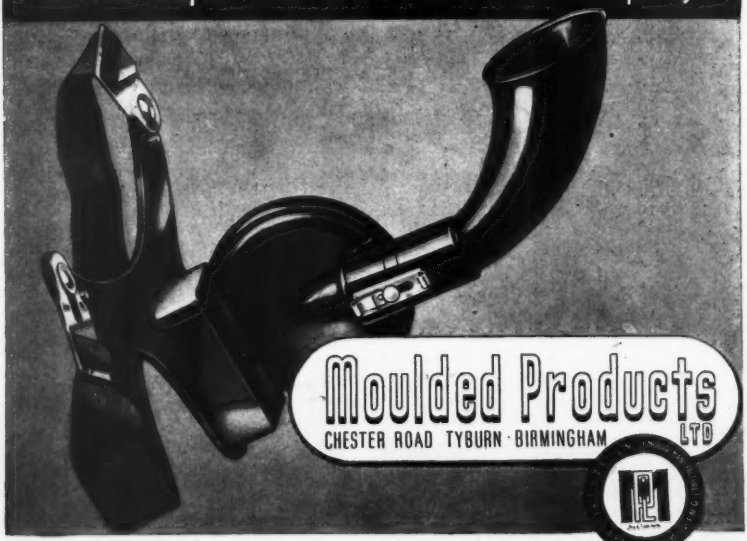
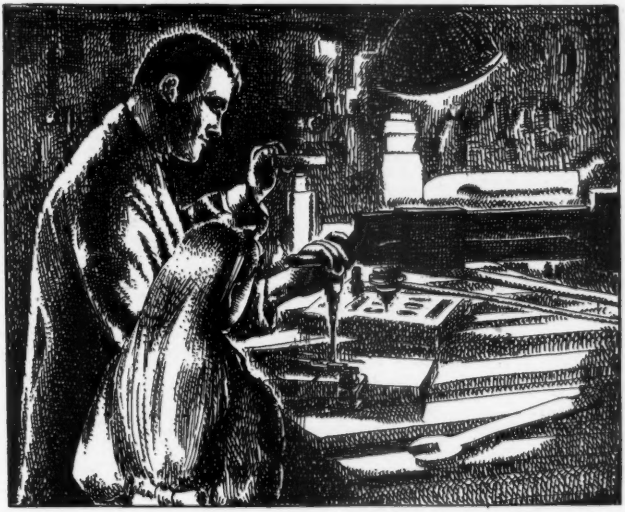


Alice in Plasticland—No. 10



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"What a self-contained place this is," thought Alice. Every process under the same roof. She was watching the nimble fingers of the mould maker. "Accuracy and precision are the key note of this department," said the mould maker. "And the more intricate the mould the more work goes into it. You'd be amazed what a lot of work goes into the preparation of the mould for a Telephone Push Button Instrument." I certainly would, mused Alice, and moved along to a door marked Inspection Department.

ELO

PLASTICS

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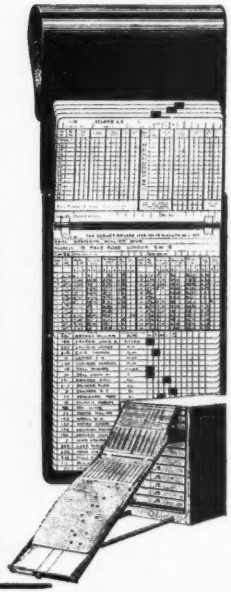

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PRODUCERS. Coal consumption reduced by 6 per cent.

ANNEALING FURNACES. A 6 per cent. coal saving per ton of steel. From what in 1942 was described as "indifferent," the efficiency of producer plant at these works is now reported to be "much improved." A mill bar furnace has improved from "good" to "very good" and an increased throughput obtained by fitting baffles in the roof.

HOW THESE BULLETINS CAN HELP YOU. The latest specialized knowledge on almost every conceivable fuel subject is at your finger-tips in the Fuel Efficiency Bulletins—advice and help that ordinarily would have to be heavily fee'd. If you've mislaid your copies, apply now to the Regional Office of the Ministry.

Issued by the Ministry of Fuel and Power

CLEVER PEOPLE, THESE CHINESE . . . though in the case of *this* imposing object the dexterity belongs to two firms on these small islands, to wit, Bakelite Limited who made the Bakelite Laminated and Messrs. J. Burns Ltd. of Chadwell Heath who so skilfully machined it. The pagoda-like result is in reality a gauge for measuring the internal accuracy of shell noses, one of the many war products being made from Bakelite Laminated.

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Vol. IX. No. 93 FEBRUARY, 1945

Plastics

Dealing with the Manufacture, Uses and Potentialities of Plastic Materials

Proprietors - - TEMPLE PRESS LIMITED
Managing Director - ROLAND E. DANGERFIELD

Editor - - M. D. CURWEN, B.Sc., A.R.I.C.
Offices - Bowling Green Lane, London, E.C.1

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NOTICES

All instructions, matter and passed proofs for all kinds of advertisements must reach the Head Office of "PLASTICS" by the 24th of each month to ensure insertion in the following month's issue.

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The fact that goods made of raw materials in short supply because of war conditions are advertised in this journal should not be taken as an indication that they are necessarily available for export.

EDITORIALS

Good Story

THE history of polythene, the plastic that has made possible so many new advances in electricity, is now out at long last, and Mr. Allen, who has done so much in its development, tells the story on another page in this issue. Mark it well, it is a British story.

Some will say "another accidental discovery!" This may be so, for the I.C.I. workers who were carrying out the examination of the reactions of ethylene gas under high pressures must have wondered at first what the white solid was that formed one day 12 years ago. It need not be considered an accident, for under the existing conditions it did form and will always form, and it became the skilled scientist's job to reconstruct these conditions and to produce the polythene continually.

We may well imagine the arduous task of finding them out and to construct a large plant to produce not ounces but tons in one of the most difficult branches of science, namely, ultra-high-pressure chemistry.

That this has been done successfully is a monument to British ingenuity in a realm which is largely British in conception and labour.

The scientific workers of this country have long been pioneers in the examination of the behaviour of gases and if we wish to go far back enough and make a longer story, we can trace the origin to the work of Robert Boyle (about 1660), Cavendish and Priestley (about 1770 to 1800), Dalton (1803) and Davy (1815).

In connection with the story of polythene, it is important to remember that Dalton first described the explosion of ethylene with oxygen, an experiment which was forgotten until Professor H. B. Dixon rediscovered it in Owen's College, Manchester, in 1891.

It was this Professor Dixon who advanced our knowledge of the combustion of gases enormously and who also began working on gaseous explosions at high pressures, using pressures of 50 to 175 atmospheres (750 to 2,600 lb./sq. in.). We can imagine how slow and difficult these experiments were in the construction, at that time, of the special compressors and bombs to obtain and hold such pressures.

As a sidelight we may mention that as a result of such experiments here, in France and in Germany, there were discovered the means of producing synthetic ammonia and synthetic nitric acid, which made possible the increased fertility of the land.

But the high pressures used by Dixon and others in those days were soon to be surpassed.

It was in 1929, on the invitation of Professor W. A. Bone (who was a pupil of Dixon's) that we visited the Imperial College of Science to see a new stage in the experiments that were being carried out on the explosion of gases, hydrogen-air, methane-air and carbon-monoxide mixtures, etc. In the new bombs we saw, pressures as high as 15,000 atmospheres could be reached, and results had been obtained which laid the foundations for new chemical processes and threw a new light on the behaviour of fuels. We well remember Professor Bone telling us that the cost of some of the equipment in the new High-pressure Laboratories was defrayed out of grants from Imperial Chemical Industries, Ltd., and the Gas Light and Coke Company of London. Of first-class importance was the fact that Professor Bone created, with his assistants Finch, Newitt and Townend, an organization of enormous national value.

From Mr. Allen's story we do not know the nature of the researches on ethylene that were being carried out when the

polymer was discovered in the reaction chamber. But we feel sure that they were in the same line of classical experiments that we have described and in which this country, more than any other, appears to have specialized. Even now the whole story of polythene is not yet possible, since so many of its uses are secret.

Post-war Expansion

THERE is every indication that the plastics industry, in all its branches, primary raw material, finished resin and other synthetic production, fabricating and moulding in all its forms, will expand or will wish to expand at a much greater rate than it is at present doing.

The problem is not merely one of an end of Plastics Control nor of release of plant, nor of personnel. It will be one more of availability of factories and of factory space than any other consideration. At least this will be true of London and perhaps also of other towns.

London is in a very special category, and in more than one special way. It has been subjected, and still is being subjected, to a ferocious bombing, the like of which, especially in its continuity, has been undergone by no other town in the country. Many factories have been destroyed, some of which cannot even be patched up, its workers have had their houses torn and blasted and have been forced to live elsewhere. It has been stated that we shall need some 4,000,000 houses in post-war London to replace this damage.

Where, then, are we to put our new factories? And, it is no use burking the fact, the demand for them will arise as soon as the European war is over, and this may be upon us more rapidly than we had dared to hope two months ago.

No doubt, London, the greatest city in the world, will be for many the most suitable site. How far can this wish be satisfied? There is a dearth of houses and a dearth of factories, and workers want to live within reasonable distance of their factories. Moreover, London, so far as Authority desires, is not to be the old London as we knew it, and many local councils are insisting that the old crowding must be swept away. We hear, for example, on good authority, that Stratford and Bow no longer wish to retain their old glue, soap and chemical works, but wish to transform themselves into cleaner, healthier and less-odorous districts. How can we do otherwise than sympathize?

It is probable that London itself will tend to diminish and that a number of satellite towns will be formed around it, but this change will take many years. What of the immediate future, so important to the plastics industry, which is growing at a rate far greater than any other?

It may be that there will be a tendency, then, to drift to Manchester, Birmingham, Glasgow, and other large towns, where conditions due to bombing have been much easier. There may, and we hope there will be, expansions of the plastics industry in towns like Southampton, where the "Barronial" efforts of local I.P.I. officials will have good effect. But these towns may have their own rebuilding and other problems, and may not be able to expand at the desired rate. For many of our future factories we must look farther afield.

We do not wish to press the case of the "distressed" areas merely because they are "distressed" areas. Indeed, they cannot be so called at the moment, although they may revert in part to that condition once war is over. Moreover, we do not know where sympathy for our own people comes in the long list of reasons for choosing a factory site.

What is a fact, however, is that few of these areas have been badly damaged, that there are or will be factories available to a much greater extent than in London, that labour (and excellent labour at that) will be plentiful, that housing for this labour is not so acute as in Southern England, and that power is cheap. These are good reasons for examining these districts for potential sites. Furthermore, the Board of Trade and local officials are anxious to help.

The Future of British Industry

MR. WILLIAM BATT, vice-chairman of America's War Production Board and U.S. member of the combined Production and Resources Board, has declared, according to "The Evening Standard," that British industry to-day is so obsolete that it has been unable to pull its weight in the war and will be incapable of meeting the demands of peace.

This seems a very bitter pill to swallow, but it is important to realize that Mr. Batt is and has always been a warm friend of this country, and that he really wishes us to improve our industries.

We cannot quite believe we are so terribly backward when we know we have produced in 4¾ years 5,700 vessels for the Navy, 4½ million tons for the Merchant Navy, 102,000 aircraft, of which 10,000 were heavy bombers, heavier than produced anywhere else in the world. This, to say nothing of guns, rifles, bombs, tanks, etc., by a nation of 46 million people, after providing an army of 4½ million, more in proportion to our population than either the U.S.A. or U.S.S.R.

His criticisms appear to be mainly directed against the coal-mining and textile industries. Because of the greater use of machinery in U.S.A., the American miner produces four times as much coal a day as the British miner. This is no doubt true, although we have heard it stated as a counterblast that some of the machinery used in America is "dangerous," and that we consider the safety of the miner of prime importance.

Mr. Batt also drew attention to our textile industry, in which Britain, with 34 million spindles, against America's 22 million, is producing only 7,700 million yards of cotton textiles, against U.S.A. production of 10,000 million yards, due to the preponderance of automatic looms in the latter country.

The true answer to all these problems lies in our comparative lack of technical and scientific training, and of technological and scientific managers at the head of our businesses. With the exception of most chemical and electrical concerns, our businesses seem to prefer having generals, diplomats and accountants as chairmen and directors.

At a recent meeting of the Parliamentary and Scientific Committee, Sir Ernest Simon pointed out that the U.S.A. is turning out twenty-five times as many university men as we are, that is eight times our rate, allowing for population.

We must wake up to our dangers.

Plastics and Retailers

ONE of the most interesting methods of maintaining contact with its potential customers has been adopted by the plastics industry of the United States. Co-operation between the Society of the Plastics Industry, Inc., and the National Retail Dry Goods Association has resulted in the publication of "Plastics, A Handbook for Retailers."

The entire range of plastics in the consumer merchandise field is presented in non-technical language, and the characteristics and typical applications of each type of plastic are described. A primary purpose of this unique collaboration between the rapidly expanding plastics industry and the National Dry Goods Association publication is to establish the facts about plastics consumer goods and emphasize that all plastics are not alike.

Featured in the 34-page illustrated handbook are a "capsule encyclopædia of plastics" and a chart which defines every trade-named plastic in terms of its basic type and characteristics in use.

The chart rates each type of plastic for strength; resistance to water, heat, outdoor exposure, household chemicals and solvents; and for the range, brilliance and clarity or transparency of colours obtainable. A complete list of typical consumer items for which each variety of plastic is used is included, under sub-heads which indicate whether the items are made by moulding, fabricating or extruding the plastics materials. The field of non-rigid plastics, which includes coatings, as used in shower curtains, tobacco pouches, umbrellas, etc., is covered in a separate section of the chart.

Tropical Packaging

Which Includes Protection from Deterioration by Corrosion, Mould Growth, etc., Mechanical Damage, Packing and Labelling

By E. E. HALLS

THE expression "tropical packaging" carries with it a full significance of its meaning, aptly and concisely. It may be that it is too concise, with the result that too much is taken for granted, that the immensity of the field covered is overlooked, that the needs of each specific case are not fully considered, and materials, processes and methods studied. The needs and requirements for tropical packaging have not fundamentally changed in recent years, and the general methods of successfully meeting the demands have not fundamentally altered apart from the introduction of a few new procedures. These latter, to those not closely concerned and intimately knowledgeable upon what is involved, appear as spectacular methods. Actually they represent sound developments by packaging specialists, who have been quick to perceive the merits of some of the newer materials, and rapid to adapt them to their particular sphere of application. They utilize plastic film materials which possess very low values for moisture permeability, or plastic dopes likewise having this property but which can be applied by spray from guns in much the same way as paint is sprayed, or by dip methods with the plastic molten under controlled conditions of temperature. These materials and processes do not in themselves enter the field to solve new problems, but they appear as additional means of meeting a need, the conditions obtaining still having to be fully studied and appreciated. At the same time, there is no doubt that plastics in scientific packaging can contribute to the solution of difficult problems, with much on the credit side with respect to efficiency of protection, speed and convenience in packing and in unpacking, and in overall economies, in many instances when compared with the methods involved when using other materials.

The expression "tropical packaging" is really too narrow in the descriptive sense, because not only must it embrace packing for transport to frigid zones as well as to tropical climates, but quite frequently it must include handling in temperate areas, including the home country itself. Exposure in open trucks or under leaky or improperly adjusted tarpaulins during wet weather, transport by river barge or coastal craft, accidental flooding or exposure on dock sides, can in the space of time entailed do as much harm as tropical exposure for a shorter period. Thus even "export packaging" does not fully describe the situation, and the following can be, therefore, taken as a basis of packaging in general, with the degree of effort expended and methods adopted carefully balanced to satisfy the conditions obtaining under specific circumstances.

The object of proper packaging is to ensure that the goods dispatched retain their quality in all respects, possessed at the time of inspection and packing, when they reach the customer and are finally put to use. The climatic conditions, against which safeguard is necessary, include temperature fluctuations, slow or rapid, from extremes of heat to those of cold, the limits of which must be predetermined; dampness due to humidity fluctuations with possible condensation, due to driving rain, possible flooding, sea spray or even sea-water submersion; direct exposure to sun and, perhaps, wind or dust storms. The influence of additional heat, as from proximity to ships' boilers, must not be overlooked. The packaging, consequently, must give pro-

tection against corrosion of metal work by dampness or salt, against fungi growth on textile-based materials or other substances prone to attack by moulds, against deliquescence or hydrolysis of chemicals or the decomposition of medicinals, against the spoilage of foodstuffs. The packaging must be stable to the heat conditions encountered, and flexible enough to withstand the extremes without undue softening or embrittlement or without springing a leak. Mechanically the package must be designed in shape and strength to resist damage when handled by hoist, chute, manually, etc., or when subjected to vibration, shock, jolting and the like. Obviously, not only have the conditions to be encountered to be given consideration, but the physical and compositional nature of the goods packed must also be given thought in making a decision upon the type of package.

When the goods are in small packages which themselves can be hermetically sealed the problem is much simplified, and it becomes resolved into the provision of a package mechanically sound, with additionally sufficient protection to ensure that the outer appearance of the individual packages does not deteriorate or lose its identification. Thus, in the case of foodstuffs, fish, meat, fruits, vegetables, milk, beverages, etc., hermetically sealed tins are the rule, and they lend themselves to satisfactory handling admirably. At the same time, for long periods in very wet locations, additional sealing may be desirable in order to prevent the rusting through of the cans from the outside. This is a requirement that the moistureproof film and sheet materials can fulfil. Cardboard cartons are extensively used for food products, such as cereals, and the cartons are either waxed or protected by means of waxed paper or moistureproof cellophane film wrappings. The limitations of these have to be appreciated. Cases lined with waxed or bituminized paper for moistureproofing are generally used in conjunction with the cartons for added waterproofing, but again the design of package to secure any moistureproofing at all, and the degree of moistureproofing attained, must be clearly understood. In all cases, metal pack or carton, the outer packaging has the same requirement imposed upon it to provide mechanical protection.

Many liquids, oils, solvents, chemicals and solid chemicals can utilize metal containers, such as drums or cans, but they must be appropriately finished to protect them from corrosion. Zinc (galvanized iron), tin ("tin-plate") or lead/tin alloy ("terne plate"), or paint and varnish, are extensively used. The container must be stoutly designed to carry the full weight imposed, designed for handling conveniently by provision of handles or grappling loops, and shaped to suit handling or minimum of space occupied, or both.

Engineering commodities afford their own problems. Machines, motors, trucks, communications equipment, radio, radar, telephone exchange apparatus, radio valves, precision instruments, meters, etc. Much of this type of goods is precision made; fine dimensional tolerances often prevent heavy paint or electroplate protecting finishes from being applied. Much plain steel has had to be substituted for non-ferrous metals and for stainless steel, and this, of course, makes the urge for proper packaging even more essential. Protection from corrosion as a first requirement is general; from mould or fungus growth it is necessary with any apparatus, including textile or fibrous materials in its construction; against vibration and shock to prevent the upsetting of adjustment, loosening of screws and bolts, or breakage of castings it is also needed. Bracing or blocking, and the use of double packing, consisting of an inner case floated in an outer one, is the procedure by which these problems are generally solved. The double casing makes easier the problem of lining one of them to make it moistureproof.

In lining cases, of course, a complete seal must be provided. No nails must pass through the liner to cause an inlet channel for moisture. Each "side" of the case must be covered, and the

moistureproofing material taken around abutting ends, and there the junction of the end of one side with the face of the next must be sealed with suitable plastic, or if metal lining is used, by means of solder. The free air space in the container should be minimized, and, for preference, a drying agent included to take care of the water vapour already present in that air as well as in the goods, together with that small quantity which will still pass through the moistureproof material.

Packing of goods in this category in hermetically sealed cases can greatly be assisted by providing proper packaging areas, consisting of air-conditioned rooms in which temperature and humidity are controlled. Also, all packing accessories, such as wood blocks, paper cuttings, wood wool, felt, etc., which are included in the sealed portion of the package, should be dry, and a drying chamber should be available for them.

Firms accustomed to export business in machinery and apparatus are familiar with the use of waterproofed cases, using paraffined or waxed paper, bitumenized paper or lining felt and metal liners, and with the steps to take to ensure adequate sealing and mechanical protection. Some official specifications have always stipulated this type of packaging. On the other hand, with the increased production of war equipment and dispersed manufacture, many technicians and executives are not so well informed, and certainly transport and storage conditions with respect to protection from weather and care afforded to handling are much below the standard necessary.

This article will first give a brief survey of American progress during recent months towards achieving the ideal. It will then critically discuss some of these methods and materials. Finally, it will detail methods employed in this country for some years for tropical packaging of engineering equipment, with particularly the advantage and limitations of the plastics in mind.

At the outset, reference should be made to "Plastics," January to May inclusive, 1942, for general information appertaining to plastic sheet and film materials, particularly with respect to moisture-proofness and stability. Again, in "Plastics," January, 1943, page 74, the saran type of film (polyvinylidene chloride), and also polythene in thin film form, were briefly discussed from the same angle.

Again, from the outset, a clear appreciation of the difference between waterproofness and moistureproofness must be envisaged. The first indicates resistance to the passage of liquid water, and the second to that of water in vapour form. A waterproofing treatment does not provide moistureproofness necessarily—in fact, it rarely does. On the other hand, moistureproofing must of necessity ensure waterproofness. Both terms are used in a relative sense. Rolled metal sheets and foils are moistureproof, i.e., they do not permit the passage of moisture-vapour through their thickness, whatever the differential of water-vapour pressure between the two opposite sides. Rubber, bitumen, pliofilm, polythene and polyvinylidene chloride are very nearly moistureproof, sufficiently so to be accepted as such for practical purposes. The cellophanes are rendered moistureproof by superficial treatments. Papers are made relatively moistureproof by heavy wax impregnation or by bitumen impregnation. Lining felts are virtually roofing felts, and they possess quite good moistureproofing properties by virtue of their structure and composition, namely, matted or felted paper fibres impregnated thoroughly with bitumen. A number of materials are waterproof, and their appearance gives the impression that they should be moistureproof, but they are not. Cellulose acetate, cellophane, hydrated or glascine paper, and parchment or greaseproof paper, belong to this class, which have no properties of moistureproofness, or only poor qualities in this direction.

It has been shown before that moistureproofness is a property that is dependent upon the compositional and physical properties of the material. It is, of course, dependent upon the humidity gradient, which, for the present purpose, is the

difference between the water-vapour pressure inside the container and that of the general external atmosphere. Temperature is involved in so far as it affects this humidity gradient. For the present purpose it is sufficient to recall the fact that, for thin film materials, moistureproofness does not necessarily increase with the thickness of the film, but that more generally it decreases. For greater thicknesses, the line of distinction lying, perhaps, between 0.005 in. and 0.010 in., improved moistureproofness can be obtained from a greater thickness of the material, provided, of course, that it is identical in other respects. However, it must not be thought that this moistureproofness quality is the only criterion involved. Mechanical strength and flexibility and capacity of being sealed are other important characteristics which enter, and ultimately a compromise may be necessary.

H. A. Knight gives special attention to rust preventers and processes for their application in an article entitled " Protection of Steel Parts for Overseas Shipment " in " Metals and Alloys," October, 1944, vol. 20, No. 4, pp. 934-940. In this an account is given of various aspects of the action taken to correct the damage experienced during 1942 and 1943 to services stores for the U.S. Army. Losses from mechanical damage and corrosion were critically high during this period, and the technical resources of American industry were mobilized to devise protective materials and packaging methods for the transport of all supplies and their delivery in an undeteriorated condition, free from rust or corrosion, devoid of mould growth and mechanically undamaged. Further, the object was to achieve this without introducing delays at any stage, namely, in production, in shipping or ultimately when putting the equipment into commission. It is claimed that successful solutions have been arrived at and that they are sufficiently logical to provide the basis of post-war procedures. The following details are taken from H. A. Knight's account of the subject.

The disgust and disappointment of the Services awaiting in advanced battle fronts for equipment, replacements and repair parts, perhaps under conditions of critical urgency, then receiving them in an utterly useless condition due to rust and damage, is difficult to appreciate fully at this distance. Apart from preventing them from tackling their task efficiently under conditions that are in any case unenviable, there are other factors involved. The effort expended in manufacture and, more particularly in transport, man-handling at various stages, train, lorry, barge, boat, landing craft, raft, human-chain, mule, etc., etc., one or all, according to local conditions, stretches manpower to the extreme, and wasted energy can be ill-afforded. In fact, a smaller quantity safely delivered is preferable to out-of-condition supplies, and the manpower saved is 100 per cent. on the credit side. C. M. Parker, Secretary of the Technical Committee of the American Iron and Steel Institute, critically but effectively asserts " Pack it right to reach the fight," and this aptly describes the American effort that has borne fruitful results. He points out instances in which steel products are loaded and unloaded from railroad cars, ships and trucks, 22 times before reaching their final destination, with very little of the handling done by experts. Further, he states that at one stage the fate of Stalingrad depended upon getting American cold-rolled-steel strip through safely, and that it is when steel has been worked cold that rusting is most progressive. Incidentally, a Russian metallurgist gives the information that steel plates were transported for long distances from the ship side by Russian women, strafed by German aeroplanes. Bullets knocked the scale off these plates, and, getting into the women's eyes, this did more damage than the bullets. Heavy grease was thereafter applied instead of oil to the plates, and it served to hold the scale as well as to function as a serviceable rust preventer.

When such effort has to be expended to protect plain steel in the raw material condition, it is evident that much more care is warranted for machined com-

ponents, especially those made to close dimensional tolerances, and those having bearing surfaces, and for equipment, especially instruments such as range finders and communications apparatus such as telephones, radio and radar.

America has, therefore, become packaging conscious. A jeep requires one-third of its weight in packaging material and a cargo trailer about one-half. Lack of personnel and insufficiency of space are shortcomings that have been corrected. Packaging is recognized as a specialist's job and one which requires planning and putting into effect by the specialists associated with each particular industry. Not only are the many phases of engineering implicated, but all other industries are concerned; food, clothing, medical supplies and chemicals, all require their own specific needs fulfilled. Attention has to be given in order to ensure that boxes, crates, kegs, burlap bags, etc., arrive at their destination without being torn open, that goods do not arrive broken, bent or otherwise distorted, damaged or corroded, or completely missing. The influence upon the production of packaging materials can be amplified by the growth of waterproof paper production—200,000 tons to-day against 16,000 tons two years ago. The Ordnance Department uses 12 million to 15 million square yards of acid-free greaseproof paper a month.

U.S. Army and Navy specifications demand that ordnance should be packed to resist temperatures from −40 degrees F. to +130 degrees F., the extremes from Iceland to Guadalcanal. Corrosive elements are salt water and spray, fog, rain and sun. Rarer hazards are coral sand, which has a very severe abrasive action, and sulphur fumes exuded from jungle swamps.

To meet these requirements, materials and methods or processes have been developed and designed to suit all individual cases. Materials include oils, greases and waxes, but particularly synthetic plastics for dip application; plastic compounds for spray application; and moistureproof plastic film materials in which to " bag " the equipment. In this last respect a bag has been produced for packaging the soldier himself. It is carried in a compact package designed for split-second use for protection against irritant war gases. It is of the Saran type of plastic, completely covering the man, opaque for the greater portion, but transparent at the top for sight and with an opening for the rifle. Materials also include a wide range of greaseproof and waterproof papers, bitumen-sandwich plain and crepe papers, plastic foils, metal-foil-covered materials in which the backing may be plastic; or canvas type of material or paper. They embrace shock-proofing pad products such as rubber-covered felts, and other types of treated felts. Packagings include treated cardboard boxes, wooden cases, and especially double packs in which the inner one is floated in the outer. Moistureproof linings are included. Metal boxes are not neglected, nor are completely plastic containers. The use of moisture absorbents such as silica gel in calculated quantities to take care of the amount of moisture which can pass through moistureproof membranes under specified conditions of vapour pressure gradient, temperature and time, is an important advancement.

A few examples of some of the latest methods for preservation, using plastic materials, can be quoted. One of the most important of them is the use of a plastic compound having a vinylite resin base, this compound being applied by spray. It hardens in less than 30 minutes and gives a protective coating which hermetically seals the contents. In this way protection from heat and cold, driving rain or salt water can be obtained. This method is employed for the protection of aeroplanes shipped in a completely assembled condition on ocean-going freighters. For " unpacking " upon arrival at the destination the plastic coating can readily be stripped off by three or four men in an hour. The plastic scrap peeled off in this manner can be salvaged and remelted for using again. This procedure not only saves the labour required for disassembling aircraft for

shipment and then reassembling, but it gives better protection. The various petroleum compounds that were previously used and which were waterproof were not moisture-proof. Again, with petroleum compounds, it is difficult to strike the best consistency to suit wide variation in weather conditions from hot to cold. Compounds would either drip under excessive heat or crack due to excessive cold. Also, solvents are required for their removal, and removal is slow, an average of 250 man-hours being involved.

The vinylite resin coatings have been designed to give an elastic film which is flexible with the movement of the plane, and it does not harden or become brittle upon exposure to wind, sun or cold. To remove it, it merely has to be slit and stripped and it does not lift the paint with it. Further, it possesses a very low moisture vapour transmission rate.

Test results show that a two-coat film of vinylite resin 0.003-in. thick transmits only 0.47 gram of moisture per 100 sq. ins. in 24 hours. A three-coat film of thickness 0.00045 in. transmits only 0.29 gram. Another modified compound in a thickness of 0.006 in. transmits 0.18 gram. The Army and Navy specifications state that materials are moisture vapour proof if they have a maximum transmission rate of 0.25 gram of water per 100 sq. ins. at a moisture vapour pressure differential of 42 mm. of mercury at 100 degrees F.

The coating is claimed to fill and seal all the smaller seams of the package so that taping, which was formerly needed for this purpose, is eliminated. Small openings in an article can be covered with heavy tape and larger ones with plywood fillets. The job is then sprayed with three coats of the resin base material. An aeroplane can be coated by two men in less than one hour. The skill necessary is easily acquired and the material is applied in a continuous film, which is thus able to protect completely the article covered.

Suppliers of vinylite resin materials for these spray coatings are Aviation Packaging Corporation, Better Finishes and Coatings Incorporated, Dade Bros. Incorporated, Irvington Varnish and Insulator Co., and Plastiphane Co. of America.

The Dow Chemical Co. has developed a plastic packaging material which is applied by dipping. It is known as Stripcoat and is apparently an ethyl cellulose material. It is designed to eliminate the operations of applying preservative, cutting grease-proof wrappers to the proper size and wrapping the part. It is applicable to all metal parts having continuous outer surfaces, but also can be applied to numerous articles having internal surfaces. For example, a spark plug can be coated if it is dipped vertically, because the Stripcoat will bridge the opening and prevent the molten Stripcoat from travelling to the inner surfaces from which it would be hard to remove. Dipping may be performed manually or automatically. It may be removed easily by stripping, and a 60-95 per cent. saving in packaging time is claimed.

Typical applications are to gear wheels and crankshafts. The double dip can be resorted to with overlap of the two coats to ensure no possibility of the entrance of moisture.

Army and Navy specifications for packaging are similar, and although in the past Service conditions have been regarded as more stringent for the Navy, to-day they are equally hard for Army equipment which has to travel long sea voyages. Packaging is classified under three main divisions, namely:

Method (1). Unsealed wrappings.

Method (2). Sealed wrappings.

Method (3). Wrappings containing a dehydrating agent.

In all cases preservation of equipment must bear in mind the following steps:—

(a) Cleaning for the removal of oil, grease, finger marks and other contamination.

(b) Applying the preservative compound.

(c) Wrapping in a grease-proof or moisture-proof barrier or a combination barrier.

(d) Sealing against the penetration of water or of water vapour.
(e) Cushioning, blocking or bracing.
(f) Cartoning.
(g) Boxing or crating.

Items (a) to (d) inclusive refer to protection against corrosion, while items (e) to (g) refer to protection against mechanical damage.

It must be ensured that the various materials employed are compatible with one another as well as with the wrapped article, otherwise chemical action can be set up and corrosion of the article caused. Packing papers have to be acid free, and the possibility of the liberation of hydrogen sulphide must not be overlooked. Cleaned surfaces must be wrapped immediately before contamination is possible or before corrosion can start. Perspiration from finger-marks is actively acid and corrosive, and on work that has been soldered every precaution should be taken to ensure freedom from soldering fluxes.

For pre-cleaning iron and steel work, solvents for the removal of oil are satisfactory, trichlorethylene being typical, with perchlorethylene or other chlorinated hydro-carbon solvents and petroleum solvents as alternatives. Alkaline cleaners may be necessary for removal of dirt or solid contamination and for the removal and neutralization of fingerprints. American practice is, therefore, to use solvent cleaning followed by an alkaline treatment and then thorough washing in water. Drying-off has to be complete and can be done by oven or air blast, but in the latter case attention must be given to see that the air is dry. The preservative is applied immediately after the cleaning, and wrapping likewise quickly follows.

Of the three packaging methods briefly mentioned above, Method 1 refers to the process of applying the preservative to the article and then wrapping the article in grease-proof paper, through which the preservative will not percolate, without giving any attention to providing a seal; that is, the wrapping allows the free transfer of air or moisture vapour to and from the part. It is applicable to non-precision parts such as semi-finished castings, solid shafts or rods, springs and metal stampings.

Method 2 is for parts having precision and highly finished surfaces. The method entails rust-proofing and sealing. The preservative is applied direct to the part, which is wrapped in grease-proof paper and then the wrapping is sealed, for example, by dipping in a hot wax-like compound; usually a double dip is applied in the two directions so that the two coats overlap. Examples are, pistons and rings, taps and dies, and precision hand tools.

Method 3 provides for the part to be sealed in a moisture-proof wrapping containing a dehydrating agent. In this case the article is not treated directly with the preservative. The dehydrating agent absorbs the moisture which exists in the air inside the wrapper and any moisture that percolates through the wrapper by virtue of its small moisture permeability value, while the wrapper gives protection against high humidity, rain, sea spray, and the like. This type of package is obviously applicable to assembled equipments, instruments and delicate mechanisms, as well as to articles comprising a mixture of metallic and non-metallic parts.

In Methods 1 and 2 grease-type preservatives are generally considered the best type of compounds for storage and export shipment. Normally they are applied by dipping, using a temperature between 160 and 200 degrees F. Alternatively, they may be applied by brush or spray if these methods are more appropriate to the particular type of work. Soft greases are generally preferred for smaller articles and hard greases for large components. The chief objections to compounds of this nature are messiness in handling and the necessity for removing the preservative when the component is put into service. Table No. 1 shows the principal types of preservatives in use in America with their characteristics and source of supply.

Method No. 3, that is, packaging with silica gel absorbent, is based on the experience that moisture will not corrode most metals if the relative humidity is maintained below 20 per cent. Silica gel as dehydrating agent maintains this

Fig. 1.—A shaft is being dipped in Stripcoat, made by the Dow Chemical Co. The coating can be applied manually or mechanically, the latter providing more uniformity of coat. Ideal dipping temperature is 375°F.

humidity value. It can absorb quite large quantities of moisture, i.e., at least 8.5 of its weight in order to keep humidity below 20 per cent. The drawback with it is that it is active only for a limited time, and when it has become exhausted the package must be opened and the silica gel replaced. The U.S. Navy Specification requires the inclusion of sufficient dehydrating agent for protection over a period of 18 months. Precautions must be taken, of course, to keep the silica gel dry so that it is in good condition when it is used, but the spent material can be recovered by baking.

The U.S. Army Specification provides a useful formula from which to determine the quantity of silica gel required, i.e.:—

$$W + 0.2A = 0.5D$$

in which W is the weight of silica gel in lb., A is the area of the enclosing wrapper in square feet, and D is the weight of the enclosed hydroscopic material, such as cartons, etc.

Silica gel for dehydrated packaging is manufactured by the Davison Chemical Corpn., Baltimore; Permutit Co., New York; American Cyanamid and Chemical Corpn., New York; Morgan Incorporated, Chicago, and International Filter Co., Chicago.

One of the most important developments for war packaging is considered to be the material known as Grade C Wrapper, which is impervious to oils and greases, and it also has a high resistance to water and to water vapour transmission. The original C wrapper was used for the protection of underground pipe lines, and this was adapted. It consisted of a sheet of cellulose acetate plastic, laminated to a sheet of muslin, with a micro-crystalline wax-base compound.

Fig. 2.—Saran film is a one-ply transparent moisture barrier, developed by Dow, ideal for precious parts and instruments and ready for use on arrival.

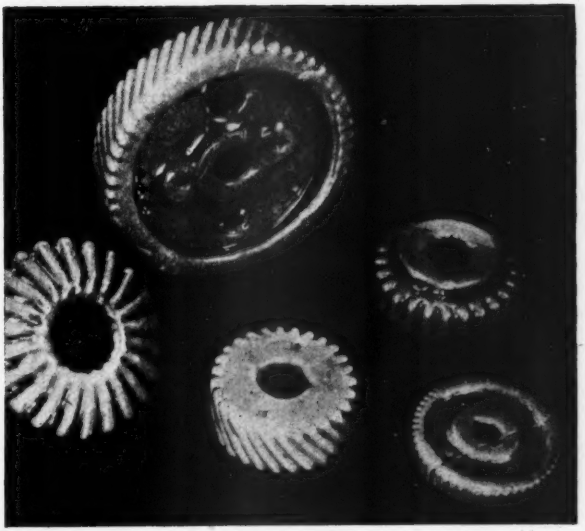


Fig. 3.—Gears are often double-dipped in Stripcoat, with a good over-lap joint to insure against entrance of moisture.

This has been supplemented by other similar materials, including cellophane or cellulose acetate laminated to paper with micro-crystalline wax, and various metal foils, laminated to paper with asphalt-base compounds.

Recently developed plastic film materials, such as Pliofilm and Saran, as well as certain kraft paper, asphalt laminations, are being used as moisture vapour barriers. With the use of these the introduction of a lead sealing ring is an innovation. For example, a machine-gun after its preliminary treatments is inserted, together with the package of dehydrating agent, into a knitted bag. This is then placed inside a tubular section of transparent plastic material, such as Saran. The ends of the tube are gathered together and passed through a small lead ring which is crimped tightly by means of a small hand press. This seals the envelope. A second knitted bag and a specially designed wooden box complete the package. With such packages, if it is necessary to re-open, a screw-driver or punch is all that is necessary to loosen the lead seal, which subsequently can be replaced on the plastic package and recrimped with a hammer blow.

Fig. 4.—A malleable lead seal ring is often used to close the opening of a film bag in which may be a machine-gun or metal part. The malleable lead ring can be squeezed tight.

Saran is made by the Dow Chemical Co., and the special lead rings by E. J. Brooks, of Newark.

The skin coatings of the Stripcoat type have many important advantages, but the chief are the saving in manpower and floor space. Much less handling and equipment is required for this type of packag-

Fig. 5.—The ethylcellulose coating, made by the Japan Co., Cleveland, has been stripped off this part, which is then theoretically ready for use.

ing. One drawback, of course, is the loss of protection if the coating is damaged, and generally it is necessary to safeguard against this by the design of crate. The operating temperature for this plastic is between 325 and 375 degrees F.

For hot dipping, waxes or Stripcoat, special equipments have been designed and are marketed by Aeroil Burner Co., New Jersey. This equipment is electrically heated and portable, and types are available for both spraying and dipping. The plant includes the dip baskets, heavy-duty grilles, built-in thermometers and thermostats, so that automatic control can be achieved within the range 100-550 degrees F.

The Japan Co. of Cleveland have also introduced a plastic material for skin-type wrappers. The material is an ethylcellulose base plastic, and it is claimed to enclose the article in a tough cohesive film which makes air and moisture penetration impossible.

The Sherman Paper Products Corpn., Mass., have issued a War Packing Manual containing samples of papers called Corroflex; these are claimed to be grease-proof, acid-free, non-corrosive, mouldable and sealable. Some of them are corrugated. Again, the Angier Corpn., Mass., market a material called Induwrap, which is called a dual paper. It is claimed to be a corrosion inhibitor as well as an oil barrier, which prevents slushing oil penetrating from the outside of the package.

Prominent manufacturers of ordnance wraps are McLawrin-Jones Co., Mass.; Rhinelander Paper Co., Wis., and Nashua Gummed and Coated Paper Co., N.H.

The American Resinous Chemicals Corpn., Mass., make emulsions, solutions, hot melts, heat-sealing compounds, etc.

Fig. 6.—Application of corrosion preventive and protective wrappers for a crankshaft, as recommended in Army Service Forces Manual M406. Grade A and C wrappings are defined in Ordnance Dept. Spec. AXS-840. 1.—Apply rust preventive. 2.—Wrap with Grade A. 3.—Wrap with Grade C. 4.—Seal with special wax. 5.—Wrapper for mechanical protection.

Table 1.—American Preservative Materials Now in Use and Their Manufacturers.

American Iron and Steel Inst. Type No.	Army, Navy and Fed. Specs.	Characteristics	Manufacturers
AEX	2-82C AN-C-52 (type 2, grade B) AXS1001	Hard, thick-film, heavy compound, protracted (several yrs.) corrosion prevention of highly finished parts; applied by heating to right consistency (no solvents), then dipping, spraying or brushing	Alox Corp., Niagara Falls, N.Y. American Lanolin Corp., Lawrence, Mass. American Lubricants, Inc., Buffalo, N.Y. American Oil and Supply Co., Newark, N.J. Anderson (F.E.) Oil Co., Portland, Conn. Ball Chemical Co., Pittsburgh, Pa. Black Bear Co., New York, N.Y. Bray (O.B.) Co., Los Angeles, Cal.
EEX	2-84b AN-C-52 (type 2, grade A)	Soft, thick-film, light compound; good for one year or less on highly finished items; applied like AEX	Carbozite Corp., Pittsburgh, Pa. Cities Service Oil Co., New York, N.Y. Dearborn Chemical Co., Chicago, Ill. Delta Oil Products Co., Milwaukee, Wis. Du-Lite Chemical Corp., Middletown, Conn.
CEX	AXS-673 AN-C-52, type 1 52-C-18. grade I	Solvent-containing, thin-film compound; for parts that have neither highly finished nor critical surfaces. Develops abrasion resistance on ageing. Applied without heating or dilution	Freedom Oil Co., Freedom, Pa. Frost Paint and Oil Co., Minneapolis, Minn. Glidden Co., Cleveland, O. Glyco Products Co., Inc., Brooklyn, N.Y. Gulf Oil Co., Pittsburgh, Pa. Hollingshead (R.M.) Corp., Camden, N.J. Houghton (E.F.) Co., Philadelphia, Pa. Humble Oil and Refining Co., Houston, Tex.
DEX	52-C-18, grade III	Non-drying water-soluble oil. May be a polar-type (water-displacing) material	Johnson (S.C.) and Son, Inc., Racine, Wis. Kendall Refining Co., Bradford, Pa. Lehigh Chemical Products Co., Allentown, Pa. McCambridge and McCambridge Co., Baltimore, Md
EEX	AXS-702 O.S. 1362	Light, non-hardening, very-thin-film lubricating oil; excellent temporary protection. Applied without dilution	Nox Rust Corp., Chicago, Ill. Pennzoil Oil Co., Penn, Pa. Penola, Inc., Pittsburgh, Pa. Presstite Engineering Co., St. Louis, Mo. Quaker Chemical Co., Conshohocken, Pa. Quaker State Refining Corp., Oil City, Pa.
FEX	—	30-50% non-volatile varnish	Rosco Laboratories, Inc., Blawknox, Pa. Scholler Bros., Philadelphia, Pa.
GEX	—	Primary coating (8-12% non-volatile soluble varnish-base residual on steel) applied in the form of a hot water solution	Shell Oil Co., New York, N.Y. Simoniz Co., Chicago, Ill. Socony Vacuum Oil Co., New York, N.Y. Sonneborn (L.) Sons, Inc., New York, N.Y. Standard Oil Co. of Indiana, Chicago, Ill. Standard Oil Co. of New Jersey, New York, N.Y.
HEX	AXS-674 O.S. 1363	Non-hardening, thin-film, medium lubricating oil. Used on internal highly finished surfaces. Applied without heating or dilution	Standard Oil Co. of Ohio, Cleveland, O. Sta-Vis Oil Co., St. Paul, Minn. Texas Co., New York, N.Y. Thompson Paint Co., Pittsburgh, Pa. Turco Products, Inc., Los Angeles, Cal. Union Oil Co. of Calif., Los Angeles, Cal.
JEX	—	Bituminous-base, quick drying, hard film	Viscosity Oil Co., Chicago, Ill. Zophar Mills, Inc., Brooklyn, N.Y.

Regarding mechanical protection against shock the general methods adopted using wooden packing cases, double packing cases, springs, packing pieces, etc., are well known. Methods for wiring boxes, with tools for wiring and unwiring, have been extensively developed. The use of strong alloy steel wires gives strength and resistance to shock.

The photographs accompanying this article are taken from Mr. Knight's paper.

(To be continued)

PROLITE.—Protolite, Ltd., a subsidiary company of Murex, Ltd., has published an excellent catalogue dealing with the use of Prolite tungsten carbide in its application to cutting tools and, because of its wear resistance and chemical inertness, in the following industries. In the machine shop "Prolite" is employed in the form of support blades, lathe centres, plug and ring gauges, in metal manipulation as dies for wire drawing and other purposes, in the chemical industry as pelleting and tableting dies to resist wear and corrosion, and in the textile industry as guides, bushes and eyelets. The booklet is profusely illustrated and contains a large number of tables for workers' needs. Copies of this catalogue will be gladly sent to readers, who should write to Protolite, Ltd., Central House, Upper Woburn Place, London, W.C.1.

LETTERS TO THE EDITOR

Pulp Reform Mouldings

I have just returned from America and have seen Dr. Haefely's letter in the December issue of "Plastics."

It was unfortunate that I could not be present to read my paper to the London Section, but I thought it would be better for Mr. Nochar, my chief assistant, to read it, than to have a last-minute cancellation.

I have read this paper myself in various parts of the country and have found a great interest shown in the process. Our inquiry file for pulp preformed mouldings would, I think, rather surprise Dr. Haefely.

I presented my paper to the Institute as something new to our industry. It has been received as such and the stress I have laid on the relation between the beating treatment, the pH, and the final strength of the moulding has, so far as I am aware, never before been explained to our members.

The addition of a synthetic resin to the beater was not the main point as paper makers have been applying resin size and fillers by similar means for many years.

Only two references were given, as I thought they might be of interest to my listeners, one being a reference to Corolite, referred to in connection with uncooked fibres, and the rather scathing "plastic catalogue to read by the fireside" was uncalled for. Particularly so as at a previous meeting one listener complimented me on the pulp-making facts, but deprecated the very small amount of plastics information.

If dates are important, I made my first experimental mouldings in 1915, whilst at school, with specially beaten fibre containing a high percentage of precipitated rosin.

Dr. Haefely quotes a couple of hundred tons of Panilax have assisted the war effort. May I ask, sheets or mouldings? For our part, over 4,000 turret gunners' seats moulded from preformed pulp have also assisted the war effort. These were made with a small pilot plant built from scrap, and to put my process on a production basis akin to Panilax would require specially designed machinery not obtainable under present conditions.

The following facts may be of interest:—

(1) Panilax.—Quoting from Micanite and Insulators, Ltd. Pamphlet PM-1/43.

"Panilax" is our registered trade name for materials made with aniline-formaldehyde resin. Although this is a thermoplastic resin, its softening point is above 100 C., which permits the use of Panilax at temperatures generally regarded as requiring a thermosetting resin. It is resistant to alkalis in the usual industrial concentrations, and is unaffected by water, organic solvent, or hot oil.

Two products are manufactured, Panilax moulded resin and Panilax laminated sheets and bars.

Panilax moulded resin is the aniline-formaldehyde resin, without filler, pressed in heated moulds into sheets and other forms. Only simple shapes, compared with the more usual phenol-formaldehyde resin mouldings, are possible, but the moulding can be machined into a more complicated form without impairing any of its characteristics, so that sections otherwise too thin can be achieved. The good mechanical properties, combined with negligible moisture absorption, are features of Panilax resin mouldings which make them particularly suitable for high frequency electrical applications or as an alternative to ebonite.

Panilax moulded resin sheet is made approximately 22 ins. square in thicknesses from $\frac{1}{8}$ in. to $3\frac{1}{4}$ ins.

Panilax laminated sheet and moulded bars are made from a special paper in which the aniline-formaldehyde resin is precipitated in the pulp prior to the manufacture of the paper. This paper is pressed up to form boards, and moulded rods which have good mechanical and electrical properties, and can be readily machined.

The standard sizes of Panilax laminated sheet are 80 ins. by 30 ins. and 40 ins. by 30 ins., in thicknesses from 1/32-in. up to $1\frac{1}{2}$ ins.

Additional information, including electrical characteristics, is contained in pamphlet PX-2/41.

Panilax Laminated Sheet.

Izod impact strength, 0.4-in. by 0.4-in. section	0.8 ft.-lb.
Water absorption, $\frac{1}{4}$-in. thickness	0.4 per cent.
Specific gravity	1.35

(2) Pulp preform mouldings. Process developed at the Bristol Aeroplane Co.,

Ltd.—The pulp is beaten to obtain certain features, in particular impact strength. It is preformed to shape, dried and moulded. Deep draws and complicated shapes such as a cylindrical container with depth equal to diameter are now possible. Not by tailoring but by beater treatment. The mouldings contain a thermosetting resin.

Pulp Preform Mouldings

Izod impact strength, .5-in. by .5-in section	2.0-7.0 ft.-lb.
Water absorption, per sq. in. of surface exposed to water—	
Polished	0.0071 per cent.
Polished surface removed	0.023 per cent.
Specific gravity ...	1.3-1.4

I trust these facts will make the two materials and their possibilities clear to readers of " Plastics."

H. Carl Martin,
Bristol Aeroplane Co.

Spraying of Plastics

Our attention has just been called to an article in your January number entitled, " Plastic Applied Coatings by Spray and Dip," by E. E. Halls, Esq., and we are writing to express our appreciation of the publicity afforded by such a well-written article.

We regret, however, that you did not mention that Patent No. 551,339, due to I.C.I., Ltd., specifically acknowledges the writer's earlier patent covering broadly the spraying of artificial or synthetic resins and, furthermore, we would like to point out that nearly all the patents mentioned in your article, which relate to the spraying of thermoplastic materials, have been issued by the writer, in addition to Patent No. 538,203, which you mentioned.

C. F. Lumb,
Schori Metallising Process, Ltd.
London, N.W.10.

Thank you, America!

We consider your publication " Plastics " one of the outstanding periodicals of the industry. We find your section " Resinoids and Other Plastics as Film Formers," edited by Mr. B. J. Brajnikoff, particularly of interest and value.

I wish to make inquiry as to the possibility of securing separate reprints of Mr. B. J. Brajnikoff's articles, for filing in our Research Laboratory as reference.

W. M. Wilson,
Rubber and Plastics Lab.,
Mine Safety Applicances Co.
Pittsburgh.

[Editor's Note: We fear that whilst there are such heavy restrictions on paper we are unable to print separate reprints. The problem will be reconsidered as soon as circumstances allow.]

PLASTIC TOOLING

New Use for Polythene

FOR some time, the development of thermoplastics for the production of drop-hammer punches and the top forces of press tools has received considerable attention in the U.S.A. Encouraging results in these applications have been obtained with materials based on ethyl cellulose.

Development work along similar lines has been done in Great Britain by the Bristol Aeroplane Co., Ltd. The material used is polythene, which has been found to have physical properties which made it particularly suitable for this class of work.

In making a top force, the heated polythene is cast into the bottom tool, thus reproducing the shape exactly. It is not necessary to make any allowance for the thickness of the material to be pressed in the tool, as polythene is sufficiently flexible to accommodate this without permanent deformation.

The saving in steel and man hours in making tools by this method is considerable. The development work on plastic tooling is not yet complete, but it is hoped that the Bristol Aeroplane Co. will be able to publish the results of their work in the near future.

KITCHEN-PLANNING EXHIBITION

Lord Woolton officially opened this exhibition on February 5 at Dorland Hall, Lower Regent Street, London, W.1. The exhibition consists of ten full-size kitchens, each having been designed to meet different needs. Working samples are to be seen of many new appliances to be manufactured as soon as conditions permit. Among these will be raised ovens, gas washing machines, gas-heated drying cupboards (for rainy days), etc. Plastics have been employed in " unit " furniture and for curtains and floor coverings, while colour has been used daringly on walls, cupboards and fittings of all kinds.

The History of

J. C. Swallow, Plastics Division Research Director, Imperial Chemical Industries, Ltd., formerly in charge of research work leading up to discovery of polythene and its manufacture on the full scale.

Alkathene, the polythene made in this country by I.C.I., Ltd., deserves a niche of its own in the history of plastics. Possessing properties of outstanding merit in the electrical and chemical field, it is a product of British scientific endeavour unsurpassed in the special field of high-pressure chemistry.

IN July, 1930, an important decision was taken. The management of one of the Research Departments of Imperial Chemical Industries decided that a new programme of fundamental scientific work should be started in the laboratories. This work, though in keeping with the traditions of the laboratory of high-class scientific work, was unrelated to any of the manufactures or processes then being operated and was directed towards no specific new product. The intention of the work was to broaden the field of knowledge of the mechanism of chemical reactions under extreme physical conditions.

This decision, taken at a time when an unparalleled world depression was beginning, was a courageous one, and from it has come one of the most important new plastics discovered in the past ten years. This product is polythene and its discovery arose in the following way:—

The programme of scientific work which it was intended to study was the effect of extremely high pressures on certain chemical reactions. The range of pressures selected for study, and this again was an important decision, was higher than the pressure of any industrial process working at that time, and the field chosen was 15,000 lb. to 300,000 lb. per sq. in. The work began in 1931, and a year or more was spent in developing the technique of making and handling the laboratory apparatus for these extreme pressures. In 1932 the chemical studies began, and this first period was one of great disappointment. Few marked chemical effects were observed, and it was not until the beginning of 1933 that anything novel was found. Early that year, when carrying out a series of reactions involving the use of ethylene—the reactive gas well known to organic chemists—a minute trace of a white solid was first found in the reaction vessel in the laboratory. This product was polythene, a solid polymer of ethylene, which may be described as a solid comprising a large number of ethylene units linked together, five hundred or more, which, under the combination of extreme pressure, temperature and a catalyst, can combine to join hands in this way.

A considerable period then had to elapse before enough polythene could be made to permit a proper study of this entirely new material, and it was not until the end of 1935, when the technique of handling these enormous pressures was much improved, and larger and more efficient apparatus was available, that a systematic study of this remarkable phenomenon could be tackled in the way which it obviously required. Almost

y of Polythene

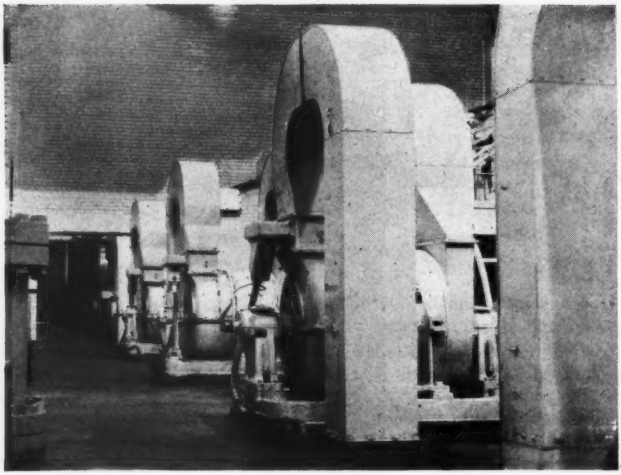
By P. C. ALLEN

P. C. Allen, Plastics Division Managing Director, Imperial Chemical Industries, Ltd., formerly responsible for development work on uses of polythene.

immediately a whole series of setbacks and disappointments were met. Attempts to repeat initial experiments were met with violent and inexplicable explosions in the reaction vessels. Until proper precautions were made for dealing with these there was a constant danger of the apparatus being wrecked, and on one occasion the laboratory was badly damaged. At length, however, by study of the reaction conditions and by paying particular attention to the purity of the ethylene gas, the reason for these explosive decompositions was found and the process brought under control. From then on progress was rapid, though the scale of the experiments was still small. Taking it all round, 1936 was a year of important advance. In that year, too, the first beginnings were made towards devising a continuous process of manufacture, which it was felt was essential if an ultra high pressure process was ever to be economical and the control of the properties of the product maintained. Continuous working with pressures above 15,000 lb. per sq. in. was no easy task, involving novel designs of gas compressors, joints, valves, tubing, reaction vessels and similar equipment. In some directions the technique used in the manufacture of artillery was drawn upon, as the pressures then being studied were of the same order of magnitude as those occurring in a gun immediately after the explosion of the charge.

By 1937 continuous running on a small pilot plant in the laboratory had been achieved, and by 1938 a proper pilot plant unit in which the basic ideas of a full-scale manufacturing process could be seen was running. During this technical development a study was also being made of the properties of this wholly novel product. It was soon apparent that this new plastic had a remarkable combination of properties in its outstanding electrical characteristics, its great toughness and flexibility, coupled with extreme water resistance and lightness. A future in the electrical industry was, therefore, promising. During 1938, when the pilot plant scale of manufacture was operating, contact was made with the electrical industry and particularly with the Telegraph Construction and Maintenance Co., who had a background of many years in the processing of gutta-percha and its use as a cable insulation, particularly in under-sea cables. This firm were quick to see the similarity of properties and handling conditions of polythene and gutta-percha and had already available machinery which could be adapted for using the new material. An experimental length of submarine cable was

(Continued on p. 72)



(Above) Polythene plant — general view of the compressor-house.

(Below) Polythene plant—general view of the control room.

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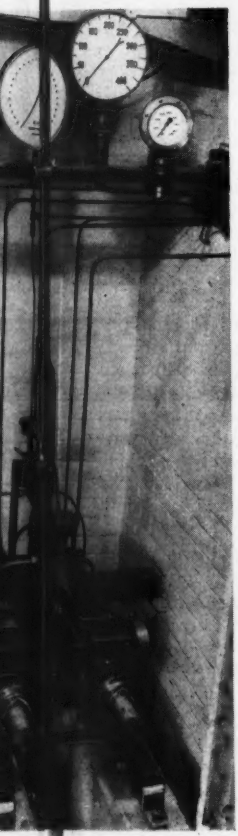


(Above) Polythene plant—view of one of the control desks.

(Below) Polythene plant—finished material running from one of the production units.

made at the end of 1938, and a mile length in July, 1939; great interest was shown in this, even in its early imperfect state, by the British Post Office. It had quickly been apparent that polythene was not only most promising for submarine telephone and telegraph cables, but that its properties at extremely high frequencies were also outstanding, which could be expected to bring it into the television field. A small quantity of polythene cable for television uses was sold just before the outbreak of war.

In 1938, too, a decision had been taken by Imperial Chemical Industries to design and erect the first full-scale manufacturing unit for polythene, involving a high-pressure reactor 600 times the size of the original experimental vessel. A design was completed by the end of the year, and erection of the plant started at the beginning of 1939. This unit came into production on the day that the Germans invaded Poland, but before it had produced a pound of polythene the decision had already been taken to double it. It is, perhaps, a strange coincidence that the availability of this new remarkable electrical insulation should have coincided with a time of the greatest need.

Value in Radar

The development of radiolocation, now known as "Radar," is a famous story of British inventiveness and scientific enterprise. It was not until after the war had begun that these two British inventions came together. In collaboration with various Government Departments, the Telegraph Construction and Maintenance Co. was experimenting on polythene-insulated cables for Radar work, and the first ton of polythene made was delivered for these experimental cables just after the outbreak of war. Experiments were satisfactorily completed by the end of 1939, all polythene delivered in the first three months of the war being used for this purpose.

By the beginning of 1940 another wartime use for polythene was under development with the Admiralty for the insulation of certain special under-water cables, but by the time of Dunkirk—and the second unit of the first polythene plant came into operation on Dunkirk Saturday, June 1—the radiolocation uses had outgrown all others in importance. All possible output was then required, and by far the greater part was diverted to Radar cable production. While equipment based on polythene was not available in time for the Battle of Britain, the decision had already been made that cables for Radar should in future be almost all standardized on the use of polythene, as, although alternative methods of insulation were available, all of these sacrificed either operational convenience, electrical performance, robustness or constancy of properties. While it is true, therefore, that Radar would have gone on without polythene, and in enemy countries it has, it would certainly not have gone on so well or so fast.

Design of an entirely new plant was begun early in 1940, and construction was started in August and pressed on with the highest priority. This plant, which had a very large capacity compared with the original unit, was completed by the end of 1941, and began production in 1942.

As can be imagined, with these extreme pressure processes considerable operating difficulties were met, but these were all successfully overcome, and at the same time a continuously rising output was maintained. At one time in 1940 much trouble was being encountered with certain compressors. When the situation was looking really serious the Admiralty came to the rescue with the loan of a machine from one of their torpedo works, the getting of which during an air raid is a story in itself.

The development of polythene in the United States is now becoming widely known, but it is interesting to note that their experience of Radar cable had closely followed ours, but at a considerably later date, polythene being manufactured in America on a full productive scale only in 1943. Early American experience with other insulations for Radar had not been altogether happy, and the decision to standardize on polythene was made in 1941. At this time an

American delegation visited the I.C.I. plants and were given all information on manufacture. Before that, however, a polythene-insulated cable had been laid in the United States as part of the multi-channel trunk telephone line between New York and Washington. The Bell Telephone Co., in the United States, who have always shown an appreciative interest in polythene, were anxious to make an experimental length of this cable with polythene insulators. The polythene was shipped from this country early in 1940 for processing by the du Pont Co., and cable was made by the Western Electric Co. and was laid on the Washington-Baltimore section of the telephone line. This piece of cable was reported to be working well in the summer of 1943.

It is possible now, when production is assured and all the requirements for Radar and military communications are easily being met in this country and in the United States, to look back almost with regret on the early struggles at the beginning of the war with new and untried plant when the need for this material was desperate, but it is really much healthier to contemplate the present position when production is stereotyped and British plant capacity has reached 200 times the output of 1939 and 2,000 times the production of 1938. The war-time history has been that the combination of two noteworthy British scientific discoveries—Radar and polythene as its handmaid—has been a conspicuous success. What the future holds remains to be seen. For Radar it is undoubtedly assured; for polythene the emphasis will, perhaps, shift somewhat from its qualities for electrical insulation to the more general part it will play as a full-grown member of the family of plastics, but its electrical behaviour will always be invaluable, and its contribution in war in the electrical field never forgotten.

LAC DERIVATIVES

Substitutes for Alkyd Resins

THE London Shellac Research Bureau has just issued an important pamphlet dealing with the above subject. It is a reproduction of an article by Dr. B. S. Gidvani and Mr. N. R. Kamath, B.Sc., from " Paint Manufacture."

The resinous materials obtained by condensing glycerol and phthalic anhydride, known as alkyd resins, when suitably modified, have found world-wide use as coating compositions. Their electrical and adhesive properties are excellent.

The shortage of both glycerine and phthalic anhydride during the war has led to a search for substitutes. Many substitutes have appeared on the market, but these fall short of expectation, especially in regard to durability, retention of flexibility and other ageing characteristics. The electrical properties of such substitutes are also not particularly good.

Compositions based on lac which do not contain either glycerine or phthalic anhydride have now been formulated. By a judicious choice of raw materials and working conditions, substitutes for alkyds have been prepared which satisfy all the requirements of the individual applications.

Coating compositions which contain lac in addition to glycerine, phthalic anhydride and a fatty acid are known. These are in every way comparable with the alkyds. They cannot, however, be considered as " true " substitutes for alkyds, as they contain both the materials which are in short supply.

The proposed substitutes contain only lac, a dihydric aliphatic alcohol such as ethylene glycol, and a monobasic acid. The acid can be either a resin acid—e.g., rosin, a simple aliphatic long-chain acid, such as oleic acid—or a mixture of acids, such as the fatty acids of linseed or cottonseed oil.

The notes give details of the production of various lac-glycol combinations and the results of tests carried out on them.

The results so far obtained clearly indicate that the electrical properties, retention of flexibility on prolonged exposure to high temperatures, durability and other ageing characteristics of lac/glycol/fatty acid complexes are comparable with (if not superior to) commercial oil-modified alkyds contain-

(Continued on p. 82)

World's Industry Employs Plastics

ELECTRICAL

New plastic junction box has wiring diagram reproduced directly on to the sensitized base plate. A formed cover of acrylic or other transparent plastic fits over the plate. The design is due to the Glenn L. Martin Co., and makes wiring much more accessible and more rapid than the conventional type of box. ("Product Engineering," 1944/15/661.) **Plastic jacketing or insulation for electric cables** is attracting considerable attention and Shackleton, of the Plastics Dept. of Dupont de Nemours, recently presented a paper on resins suitable for this purpose. Polythene and Nylon are chiefly considered ("Wire and Wire Products," 1944/19/664). It should be noted that polythene, like other crystalline resins, may be cold extended. On page 692 of the reference cited, Rolston discussed **synthetic rubber insulation and jacketing compounds** at present available. Both articles contain tables giving the physical properties of the respective materials. **To filter off visible light from lamps designed to operate with fluorescent materials,** extruded Tenite sleeves have been found very useful. The U.V. light source so obtained is used to render dials, etc., on aeroplane instrument boards visible, this taking place by activation of fluorescent material applied to them. The plastic filter (dyed by special process) and the lamp combination costs but a fraction of the charges at present entailed for mercury-vapour or carbon-arc lamps; no transformer or other equipment is needed and no intense heat is generated. ("Automotive and Aviation Industries," 1944/91/110.)

GENERAL ENGINEERING

Self-flaring coupling for flexible plastic tube needs no special tools for assembly. The flare is formed as the coupling members are screwed together. **New type plastic foam** has been produced by Pyle, of General Electric Research Lab., U.S.A. ("Scientific American," 1944/171/224). The plastic, in the course of production, foams into 30 times its initial bulk in about 10 minutes to give a material of a density less than 2 lb. per cubic ft. A more rigid type with density 7-8 lb. per cubic ft. has been developed. **Formica sheets** may be produced in curved forms by a new production process. The material is heated to a temperature just below blistering point and then quickly stamped to shape with inexpensive dies of untreated wood or resin-impregnated wood. ("Machine Tool Blue Book," 1944/50/262.) **Protection of propeller shafts,** particularly in wooden ships, is said to be improved by coating the shafts with flame-sprayed Thiokol (McGraw Hill Overseas Digest, September, 1944, p. 16). According to the same source, **flame-proof cloth** made of glass, coated with synthetic rubber, has been developed by the United States Rubber Co. It shows high tensile strength at high temperature, has high tear resistance and is extremely light in weight. Use of plastics as material for **checking the outline of profile grinding wheels** after truing, appears to represent a new application for the synthetic resins. A tough non-burning plastic is recommended, of such composition that it takes a clear, sharp outline without wearing down the wheel form. (Machine Tool

Book, 1944/140/330.) **Substitute for leather** for shoe soles consists of a cotton fabric impregnated with what is described as a "plasticizing" agent. It has proved useful for stair treads, floor covering, chute lining, oil seals, clutch facings, etc.; thickness is about 0.04-$\frac{3}{16}$ in. and the material is said to have remarkably high resistance to abrasion and attack by organic solvents. ("Product Engineering," Vol. 15, 1944, September.) **Difficulties in drawing lines** parallel to splined lines have been eased by the introduction of plastic discs perforated to take a pencil. The discs have to be carefully made to ensure the correct width of the gap. ("The Machinist," 1944/88, November 25.) **Lettering of synthetic resins** by die stamping has often presented difficulties due to the surface brittleness of many of these materials. Throp (Proc. Inst. Mech. Eng., Vol. 151/285) points out that, hitherto, it has usually proved necessary to heat the die to some extent, but, even so, a shallow impression only is possible, hence pigments or metallic foils must usually be impressed in order to render the markings readily visible. Only a few plastics may be thus marked with any satisfaction at normal temperature. **Design of rubber press tools** and the understanding of their mode of operation is facilitated by use of coloured illustrations, according to account in "Iron Age," 1944/153/50, September 14, and p. 59 September 21.

AIRCRAFT

Rangefinder for cameras for use in aeroplanes is moulded in Plexiglas. Moulding of the complete unit has so far been perfected as to include even mounting holes and undercut flange. The material is rendered opaque, where required, by black lacquer. **Markings on instrument panels** of aircraft are made clearly visible for day and night use by identification plates of Lumarith inscribed with fluorescent ink; each plate consists of two sheets of plastic; the first carrying the lettering in the special ink, bordering and trimming being by means of ordinary ink; the second Lumarith sheet finished with matt surface to eliminate glare is placed over the printed surface to protect it. **Possibility of disintegration of transparent plastic** canopies when pierced by bullets or flak whilst flying at high speeds under pressurized conditions are minimized by the use of laminated Lucite-Butacite; this consists of a single layer of polyvinyl-butyral resin sandwiched between two layers of polymethylmethacrylate. It is produced by Dupont de Nemours ("Scientific American," 1944/171/204). **Cascophan RS.216** is a low-temperature wood adhesive which cures in 8-10 hours at 70 degrees F. It is recommended for work demanding high strength and durability, such as laminated propellers, aircraft spars and built-up arches for heavy duty. **U.S. practice in forming aircraft parts from phenolic resins** form subject of a well-illustrated article in "Machinery" (London), 1944/65/673. The technique considered is that employed at North American Aviation Inc. **Plytube** plywood tubing fabricated from thin wood veneers and urea formaldehyde resin has been used to handle petrol, oil and chemicals. It can be cut on ordinary wood-working machinery and threaded with pipe dies; it has high tensile strength and a high strength/weight ratio. It is interesting to note that **A.A.F. fighter aeroplane rocket guns or Flying Bazookas** are made of paper treated with heat-resistant plastics. The tubes are hardened off in ovens, painted and assembled in clusters. (McGraw Hill Overseas Digest, October, 1944.) **Enclosures for P-51 Mustang fighter aeroplanes** are made of Polymethylmethacrylate resin, drawn in a vacuum die to eliminate contact with metallic moulding dies. In this way the optical properties of the plastic are conserved to the greatest possible degree. Without war paint the **Curtiss C.46 Commando** is faster and can carry more than

75 lb. more payload than the painted version. This is because the aerodynamic drag of the relatively rough surface of the paint is eliminated. ("Machine Design," 1944/16/98.)

MOTORS

Life of commercial vehicle tyres in which the rubber shows signs of deterioration can be extended by several months by turning or grinding down irregularities and removing flat spots. ("Iron Age," 1944/153/61, September 14.) **Treading of automobile and commercial** vehicle tyres and repairs to tyres for passenger cars, etc., is covered respectively by commercial standards C.S. 108-43 and C.S.110-48 respectively. These are issued by the U.S. Dept. of Commerce. The first standard has been accepted by about 1,750 independent concerns and 10 trade organizations; the second has been accepted by 1,400 concerns and four trade associations. **Electric vulcanizers for automobile tyres** have been developed, which embody the principle of high-frequency heating. **Mobile vulcanizing unit for army use** weighs only 500 lb. Vulcanizing is accomplished in 10 minutes as contrasted with several hours required under normal conditions, and with plant weighing, in all, some tons. ("Scientific American," 1944/171/210.) **Induction-heating units** permit effective salvaging of hard rubber from worn tyres, the base metal being sufficiently heated so that the rubber can be stripped off. ("Machine Design," 1944/16/98.) Occasion might be taken here to point out that, whilst at the moment induction-heating units of large output are somewhat expensive, this is not true of low-wattage sets and, in any case, is a condition which will be ameliorated when apparatus of this type comes into more general use.

MISCELLANEOUS

Plastics production forms subject of recent paper by Bebb, presented to the Cornish and Sheffield Sections of the Institution of Production Engineers. (J. Inst. Prod. Eng., 1944/23/421.) The paper contains numerous drawings of various types of mould for both thermosetting and thermoplastic material and can be considered as a valuable contribution to the study of mould design. **New Thiokol S.T.** is said to offer, for the first time, a successful solution to the problem of cold flow manifested by the polysulphide synthetics. It has marked resistance to this tendency of taking on permanent deformation under pressure or stress. **Effect of temperature on the properties of cellulose acetate and cellulose nitrate sheets** 0.125 in. thick is presented in the form of 10 diagrams by Nason and Telfair, of the Research Dept., Plastics Division, Monsanto Chemical Co. The temperature range investigated was from −80 to +80 degrees C.; tensile stress, elongation, ultimate strength, yield stress and modulus of elasticity were principally examined, together with sheer or impact strengths determined in various ways. ("Product Engineering" Reference Book Sheet, Vol. 15, 1944/719.) **Résumé of various basic types of synthetic rubber** is presented in a 16-page insert in "Product Engineering" Reference Book Sheet, Vol. 15, 1944. The properties of these materials and some of their principal applications, particularly with respect to moulded products, are dealt with. The types discussed include Buna S and Neoprene, Butyl, Buna Na and Thiokol. Useful references to textbooks, bulletins, reports and articles in the technical Press are added. Possibilities in application and design of **low-pressure hot-formed thermosetting laminated sheet** are dealt with in a comprehensive article summarizing the

views of four leading American concerns in this field. (" Product Engineering," 1944/15/674.) **Delignified and impregnated wood** forms subject of general account recently presented by Luce, Research Engineer to Westcraft Inc., Los Angeles. The delignification process entails chemical treatment of the wood under heat and pressure in order to convert the lignin to a soluble form and substantially remove it without destruction of the cellulose mattrix. (" Mechanical Engineering," 1944/66/654.) **Microstructure of high density plywood** forms subject of account by Marlow. (" Mechanical Engineering," 1944/66/656.) The author points out that high density plywood can successfully be sectioned by pretreatment in hot aqueous 10 per cent. sodium-hydroxide. It is shown that penetration of the impregnating medium varies widely between different samples. **Flotofoam** is a new plastic material produced by the U.S. Rubber Co.; it weighs less than 1.5 lb. per cubic ft., and for special purposes can be given a density as low as 0.75 lb. per cubic ft. (" Machine Design," 1944 / 16 / 17.) **Composite plastic** made from high-tensile surface material and resin-impregnated woodpulp core has been developed by the Glenn L. Martin Co., of Baltimore. The material is available in specific gravities ranging from that of spruce and poplar to that of laminated phenolic sheet. For facing plies, aluminium alloys and fibreglass fabric have been successfully used. **Method of preforming plastic made from Kraft pulp fibre** is described and illustrated in " Iron Age," 1944/153/56, July 20. Strength of the material is compared with that of laminated and moulded plastics. Comprehensive review of **modern packaging methods** involving the use of synthetic resin wrappers are presented by MacDonald in " Iron Age," 1944/153/52, September 21. The author discussed particularly prevention of corrosion by synthetic wraps. When **grinding plastic waste** in mills, such as laminated paper components, ignition and explosions can occur. The German Labour Ministry has issued preliminary recommendations to mitigate this danger. They apply to the grinding of organic plastic substances otherwise not considered dangerous, and to those which contain more than about 50 per cent. of inert fillers. Electric installations in mills must correspond to VDE 0165 as regards flame-proofness, etc. All conducting parts of machines and other equipment must be electrically continuous and earthed. Grinding mills must, if possible, be in a special room, and should be provided with separate motor drive, preferably coupled directly. Deposited dust has periodically to be removed. When preparing material to be milled, special care should be devoted to see that it is free from iron; in particular care should be taken that small iron particles do not enter the grinding plant; magnets for its extraction may be built into the mill. The operator must see that mills do not reach an unduly high temperature, and collecting chambers must be kept as small as possible and arranged in such a way that operatives are not endangered by an explosion. For this reason they should be provided with a light blast wall. If fine dust be extracted from the plant, pipelines must be arranged in such a way that no dust can be deposited. (" Arbeitsschutz " No. 11 of November 15, 1943, pp. 323, 324, extracted in " Kunststoffe," Vol. 34, 1944, p. 78.) According to a recent issue of the " Du Pont Magazine," this company is now making sound-recording strip of cellophane. The material is supplied in lengths of about 360 ft. and about ½ in. wide. Sound is recorded in groves parallel to the length of the strip, reproduction being via a sapphire needle. It is stated that the nature of the cellophane strip is such that surface noise is almost entirely eliminated. In addition it is sufficiently tough to be played many hundreds of times without sensible deterioration. The same issue of this magazine includes also an excellent tribute to British science and industry which discovered and perfected the ethylene polymers now known as **Polythene.**

Plastics in South Africa

By W. L. Speight

A JOHANNESBURG firm is now producing thermo-setting resins of the phenolic type. A recent product is the laminated form and is supplied in rods or tubes. A new Johannesburg concern is also manufacturing thermo-setting and thermo plastics for special requirements. Recent products are plastic screw-drivers and suitcase handles.

A director of a brush manufacturing business in Capetown, has just returned from a four-year visit to the United States, Canada and South America, studying much of the time the use of plastics with particular reference to the application of brushwork. He said that to many people the plastics industry has become the most glamorous of businesses, but few have a full realization of its limits and advantages, and a large part of the public has come to believe that anything can be made from plastics. In view of the high initial investment cost and the need for complicated plants and highly trained technical staffs, there is considerable doubt that industry will be willing to engage in production of plastic raw materials in South Africa for some time to come. We will, therefore, have to depend on overseas sources of supply for the majority of basic raw materials. Over-optimism in the application of plastics must be carefully avoided, as plastics are not as inexpensive as one is led to believe. The economy in plastics comes from the manner in which intricate shapes and patterns can be achieved, their novelty, beauty, light weight and applications successful to industries where their physical properties are on a par, or superior to, other materials. From the purely production standpoint it is worth noting that the automobile industry in the United States pays about 3d. per lb. for a finished steel part, the aircraft industry from 6s. to 10s. per lb. for a finished aluminium part. As a result of experiments with soya bean derivatives it is estimated that plastic parts for automobiles would cost about 14d. per lb.

South African firms are making lipstick containers in plastic, and also 6-in. plastic wall tiles in mottled shades. Another newly established firm is making plastic egg cups, salt cellars, dolls' tea-sets, condiment sets, bath plugs, plastic wedge heels and flooring blocks. It is said that these plastics are made solely from South African raw materials. In addition to their regular production for stock, these manufacturers have also been ready to make plastics to specification. Plastic spouts for water bottles is another line made in Johannesburg.

A new range of plastic toys is being marketed by a Johannesburg firm under a brand name. The range includes motorcars, tanks and racers built to exact scale. Plastic containers are being made for various products like cosmetics, etc., in the flat, round and other shapes and in such colours as red, yellow, lemon, black and green. The same firm is making a new type of plastic container for lipsticks, with plastic slide-holders. Yet another Johannesburg firm is making plastic cups, saucers and tumblers, one of several firms in South Africa now engaged in this type of production. This form of manufacture has not yet been on a sufficiently large scale to compensate for the present scarcity of crockery, although many people have now got over their prejudice to plastic crockery and are buying it freely when available.

THE POST-WAR CARAVAN NEED

A CONVENTION of the caravan industry will be held on February 27-28 at the Royal Hotel, London, to discuss raw materials. Its aim is to bring together the manufacturers of caravans and the manufacturers of materials to examine problems of supply and to apply the lessons of research and experience during the war. Steel, light metals, wood, wood products, plastics, insulation materials, adhesives and stoppers, paint and rubber will be represented.

The caravan industry expects to have to meet a big demand for open-air holidays after the war and also to play a useful part in the temporary housing crisis, especially for persons engaged on roving tasks during the reconstruction period.

Particulars can be obtained from the Secretary, Caravan Trade Convention, 24, Store Street, London, W.C.1.

[EDITOR: We have long indicated our opinion that the caravan industry is a very proper field for the introduction of plastics.]

Tropic-proof Wiring for Radio Equipment

How Plastic Insulation Improves Apparatus for the Export Market

By WALTER J. TUCKER

IN an article published in the October, 1944, issue of " Plastics " the author dealt with methods adopted to protect radio components intended for use in tropical climates, and it was pointed out that plastic materials have played an important part in enabling component manufacturers to cope with the atmospheric conditions prevailing in the tropics.

The protection of individual component parts, however, is not in itself an adequate safeguard, and will not necessarily ensure that trouble-free equipment is available for the export market.

Modern radio equipment consists of innumerable component parts assembled in a somewhat limited space, and tuned up to exact the last ounce of efficiency from each individual component. These components are linked together by a large number of connecting wires. A standard model receiver, for example, would contain 200-250 different major parts, interconnected by separate conductors, each of which has to be insulated from its neighbour to an adequate degree.

Obviously, the insulating materials employed to cover these conductors must be capable of withstanding the same arduous conditions as the components, and special attention must be given to prevent electrical leakages which undoubtedly would be to the detriment of the electrical performance of the instrument.

In this sphere of radio manufacture as well as in the production and protection of radio components, plastics have, and to an ever-increasing degree will continue, to be of the highest value.

The method used to insulate the wire used for making transformers, chokes and coils is usually to apply a coat of enamel or cotton or silk thread. Various types of enamel are used, including some synthetic resin components and nylon. All of these materials, however, are subject to mechanical limitations and are unsuitable for protecting the wires used for internal inter-component connections in radio apparatus.

To provide the additional protection required, either tubular sleevings, for fitting over the copper wires as assembly proceeds, or copper wire with an extruded covering of plastic or rubber compound are used.

To be satisfactory, a sleeving or extruded covering must possess adequate dielectric strength coupled with other desirable physical properties, such as toughness, accuracy of bore, chemical inertness, resistance to deterioration with age, resistance to the growth of fungus, and, finally, dimensional and electrical stability in the presence of moisture.

The adequate degree of dielectric strength must be related to the wall thickness of the sleeving. To maintain full flexibility, which is an essential requirement for the wiring of complicated and closely packed radio equipment, the total external diameter of the conductor and covering must be kept as small as possible.

Accuracy of bore is essential, so that a good " slide fit " is obtained between the conductor and the sleeving. If the fit is loose and an air gap exists between the wire and the inside face of the sleeving, then a potential moisture trap is created which will almost certainly cause trouble after the equipment has been in service for only a short time.

Toughness is a desirable property,

because the wiring is subjected to a considerable amount of twisting and bending during the assembly operations.

Chemical inertness, resistance to the formation of fungus and decay, and general dimensional stability over a wide temperature range are obvious requirements with which all readers are familiar.

Good moisture resistance is important, because moisture more than anything else is the enemy of radio apparatus in tropical climates, and it is in this quality that the plastic sleevings excel.

Moisture affects the insulation in the following ways:—

Straightforward absorption of moisture by the insulating material employed will obviously lower its dielectric strength, and breakdown is likely to occur between points at high potential. Absorbed moisture will also affect the dielectric constant and loss factor of the insulation. This will lead to frequency drift and a host of other troubles, particularly in the high frequency parts of the apparatus. After absorption of moisture has been proceeding for a short while, the sleeving itself will become a high resistance conductor, and in the confined space the water-saturated sleeving is bound to criss-cross and interconnect, so that the circuit constants of the equipment will be altered with disastrous results. It is important to remember that in radio equipment the wiring is part of the apparatus in the sense that the capacity and inductance constants of the wiring are taken into account when the equipment is being designed. If the electrical constants of the wiring are extensively changed by the absorption of moisture then the efficiency and performance of the equipment are bound to be seriously impaired.

When varnished fabric sleeving is used for wiring, one can usually find large gaps existing between the wire and the sleeving. Moisture will settle in such gaps. The lack of flexibility and excessive bulk of fabric sleevings also lead to an unsightly bunching of the wires. Moisture and fungus will be encouraged to settle and grow in such circumstances.

In the wiring of radio sub-assemblies the single-wire conductors are bent and twisted between the components they are linking together, and this treatment tends to crack and craze the varnish coating. The moisture resistant properties of the sleeving are thereby impaired.

Nevertheless, varnished sleeving is quite tough and can be made with reasonable accuracy. The woven construction ensures dimensional stability at high temperatures and in changing atmospheric conditions. When exposed to a severe water immersion test, fabric sleeving swells rapidly and then remains stable. The dielectric properties are, of course, severely affected by such exposure, and the margin of safety with fabric sleeves is

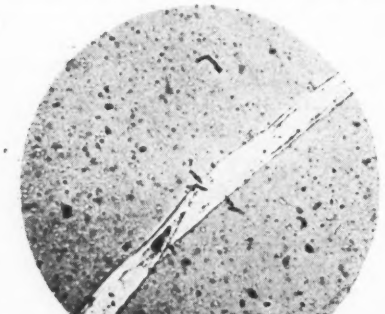


Fig. 1.—Single cotton fibre showing tubular nature (300 diameters).

Fig. 2.—Transverse section of cotton fibres showing tubular nature (300 diameters).

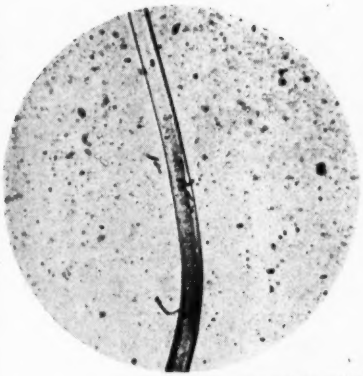


Fig. 3.—Artificial silk fibre showing solid structure.

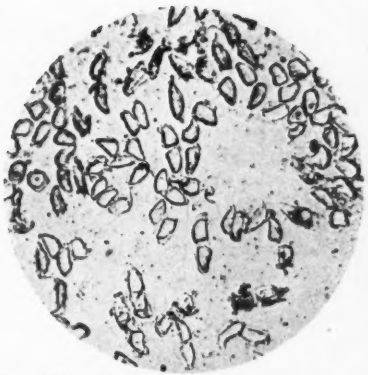


Fig. 4.—Transverse section of silk fibres (300 diameters).

Photomicrographs published with the permission of J. V. Wredden, Igranic Ltd.

much lower than that with rubber or plastic types.

Varnished fabric sleevings absorb moisture due to the difficulties encountered in actually "impregnating" the fabric. Microphotographs show that the cellulose fibres are sealed at each end* and the varnish can only settle between them. If the varnish is stressed to cracking point, or if small adjacent pockets of trapped air get linked together by twisting and turning of the sleeved conductor, a passage for the ingress of moisture is immediately created. The cross-weave construction, however, tends to oppose overall dimensional change because one thread has to act against another in opposite directions.

Rubberized fabric sleeving offers advantages over varnished fabric types so far as flexibility and resistance to moisture are concerned. Processed rubber, however, is not likely to be in good supply for this purpose, and also steps have to be taken to keep the free sulphur content of the rubber down to a minimum because of the corrosive effect of sulphur on copper conductors.

Rubberized fabric sleeving is extremely flexible and is more suited for use in high-frequency circuits than varnished fabrics. Rubber, of course, has a low dielectric constant and loss factor. The high dielectric strength of rubber also allows thinner sections to be used, and the nature of the compound is such that it can be extruded on the wire in continuous lengths, the insulation being quite easily pushed back from the bare conductor wire for soldering and jointing operations. This permits the operator to make a neat and clean joint without burning the insulation or leaving frayed and ragged ends.

Cellulose acetate is not much used as a sleeving material, although before the advent of polyvinyl-chloride it was thought that there might be a future for the former material in the sleeving industry. Even when plasticized to a very high degree, cellulose acetate exhibits a toughness and reluctance to flex, which, although an advantage in some applications, makes this plastic extremely difficult to use universally as a sleeving for flexible conductor wires.

Cellulose acetate is, however, used extensively as a rigid conduit for carrying wires, particularly in aircraft, where its qualities are extremely valuable.

Polyvinyl-chloride is an admirable plastic for use as a sleeving material.

It is tough and resistant to abrasion. It can be extruded with absolute accuracy in continuous lengths, either directly on

* Synthetic cellulose fibres are solid.

to the wire or as a separate sleeving. It does not set up chemical action, and is resistant to most of the solvents which are likely to be encountered in electrical and radio apparatus. It does not deteriorate with age, although some change may take place in the flexibility characteristics due to loss of plasticizing agents.

The loss of flexibility, however, is not of great importance, because the flexibility is required during the assembly operations only. When these operations are completed, the wiring remains undisturbed until servicing is carried out, and then any sleeving which has perished or is in any way faulty should be replaced.

The resistance of polyvinyl-chloride to moisture penetration is excellent. The thermo-plasticity of P.V.C. has been overcome to some degree by combining it with fabric sleeving. This is embedded in the plastic during the extrusion process. The presence of this fabric serves as a precaution against distortion at high temperatures. It has been found that the heating which occurs during soldering operations affects the material more than the temperature rise in the equipment itself, and when such local heating takes place the tubing tends to split along the whole length. The embedded fabric prevents this splitting. The flexibility and stability of polyvinyl-chloride are not affected down to – 20 degrees C., and for special grades – 30 degrees C. can be quoted. The fundamental properties of the material can be varied within wide limits by the use of plasticizing agents and fillers.

Polyvinyl-chloride can be made in a variety of bright colours, which makes it an ideal material for use on colour-coded wiring systems, and, by suitable processing, it can be made rigid or flexible according to requirements. It is almost completely resistant to fire, a very important factor in the wiring of inaccessible apparatus. Due to the temperature limitations, polyvinyl-chloride without the fabric reinforcement should not be used in enclosed apparatus wherein the temperature is likely to exceed 80 degrees C., or adjacent to components which may create a local temperature rise of this order.

LAC DERIVATIVES

(Continued from p. 73)

ing the same quantity and type of fatty acid. Lac/glycol/fatty acid complexes are thus eminently suitable as substitutes for alkyd resins, especially of the stoving type. The main drawback of these complexes is their dark red colour, but films from these compounds are of pale gold colour, which darkens gradually only on exposure to high temperatures.

The esters based on saturated acids, stearic, lauric, caprylic and the fatty acids of palm kernel oil have also been investigated. The stearic acid esters give films which are tacky even on prolonged baking. The palm kernel oil fatty acids, however, give non-tacky films on prolonged baking (at least four hours at 180 degrees C.), but are very soft. The colour retention of films of this ester when aged at 150 degrees C. is good. It is suggested that this ester will be useful when flexibility under continued exposure to high temperatures is required, provided the initial tack is not of importance.

The varnishes from lac/glycol/fatty acid esters can be readily pigmented, and as their acid values are low, basic pigments can safely be employed without the risk of livering. With basic pigments such as zinc oxide, the varnishes thicken considerably, and addition of xylol and a little butyl alcohol is advisable. As already mentioned, these varnishes are dark in colour and, consequently, are unsuitable for the production of white or pastel shades of enamels. These varnishes have been developed mainly for the electrical industry, where colour is, of course, of no prime importance. However, paler varnishes can be prepared by judicious choice of raw materials and working conditions. For example, using decolorized lac of the " Superblonde " type, water-white glycol and fatty acids, and carrying out all the reactions without any catalyst in an inert atmosphere, much paler lac/glycol/fatty acid complexes are obtained.

PRODUCTION NEWS

Raw Materials, New Plant, Works Organization, Control Apparatus, Research, Personal and Trade Notes

PRODUCTION AND ENGINEERING BULLETIN.—The January, 1945, issue of this Ministry of Labour publication contains many interesting articles, including: Motion Study (Part III); Annual Report of the Chief Inspector of Factories; Avoiding Waste Labour; Accident Prevention—a review of poster publicity as an aid to industrial safety; Recording Sickness Absence; Comfortable Seating—its importance in mass-production jobs, inspection, etc.; and Designing for Production. There is also included an excellent description of preservation procedure for the tropics.

GRINDING OF PLASTICS.—Dohm, Ltd., of 105, Victoria Street, London, S.W.1, inform us that they are now able to produce on their plant very fine powders from thermoplastic materials—94 per cent. through a 300 mesh. This size is now readily obtained from cellulose acetate and "Perspex." Dohm, Ltd., are also planning the commercial production of powdered polythene and nylon. Grinding of the latter appears to have gone far beyond the experimental. Also noteworthy is the high apparent density of all the powders.

RENNET CASEIN.—The Ministry of Supply have decided that the selling price of Rennet Casein will be reduced from £130 to £115 per ton as from February 1, 1945.

NEW M.O.A.P. SPECIFICATION.—A new specification (D.T.D. 636) has been issued by the Ministry of Aircraft Production for Extra High Shock Resistance Synthetic Resin (Phenolic). The impact strength must not be less than 2.25 ft./lb. (B.S.S. 771). Copies may be obtained from H.M. Stationery Office for 6d. net.

CONTROL OF LAC.—The Minister of Supply has made the Control of Lac (No. 3) (Revocation) Order, 1945, which revokes the Control of Lac (No. 2) Order, 1943. Licences are no longer necessary for the disposal, acquisition, and use of lac. Copies of the Order may be obtained from H.M. Stationery Office, York House, Kingsway, W.C.2, or through any bookseller, price 1d. (S.R. and O., 1945, No. 50.)

GAUGE AND TOOL MAKERS' ASSOCIATION.—The export drive carried out by the Association has had some excellent results. It has already received a large order for tools and gauges from the Norwegian Government and more latterly the Association has received a lengthy list for export to Turkey.

"STORES CONTROL."—This valuable little booklet has been compiled by W. N. Wright, stores controller of Frederick Braby and Co., Ltd., Euston Road, London, and is a mine of information for those in charge of stores in all industries. The subjects dealt with include: Fixing Quantity and Quality Standards; Methods of Decreasing Stock and Increasing Turnover, Stores Record Forms, Stocktaking; Storekeeping. Published by R. Madley, Ltd., 54, Grafton Way, London, W.1. Price 2s. net.

BRITISH INDUSTRIAL PLASTICS, LTD., announces a dividend of 8 per cent., less tax, for the year to September 30 last. This is the same as for many years past. Profits, after providing for taxation and other charges, totalled £21,705, against £21,659 in the previous year.

FRANCIS SHAW AND CO., LTD.—Two of the Directors of Francis Shaw and Co., Ltd.—Mr. R. O. Shaw and Mr. F. Siddall—are leaving shortly for a visit to the United States of America. Their intention is to renew acquaintance with the many connections of the company in the States and to study developments in the rubber and plastic industries, both on the processing and plant-development sides.

DE LA RUE EXPANSIONS. — An interesting development in the plastics industry is the joint work carried out by De La Rue Plastics, Ltd., and Plassey Co., on the production of fibre base-plastic bondings. To take over the process a new private company, Preformations, Ltd., has been formed.

De La Rue Plastics has acquired the business of Thomas Potterton and Co., gas engineers.

PERSONAL

MR. F. B. NIGHTINGALE, Chief Draughtsman of De La Rue Plastics, Ltd., has received the B.E.M. in the New Year's Honours List.

MR. E. A. SANDERS.—De La Rue Plastics, Ltd., regret to record the death through illness of their Newcastle representative Mr. E. A. Sanders.

CAPT. W. MALCOLM DINGLEY, Royal Artillery, has been awarded the Military Cross for gallant and distinguished service in Italy. Capt. Dingley is the son of C. S. Dingley, Director of British Industrial Plastics, Ltd.

MR. R. W. BISHOP, until recently Technical Assistant to the Ministry of Supply, Cable Planning Organization, has now joined Duratube and Wire, Ltd., as manager of their technical service department. Mr. Bishop received his initial training with the Colne Valley Electric Supply Co., and had further experience with British Insulated Cables, Ltd., the North Metropolitan Power Co., etc.

IN MEMORIAM

DR. HENRY DREYFUS.—A memorial service for Dr. Henry Dreyfus, chairman of British Celanese, Ltd., was held on January 9 at the Liberal Jewish Synagogue, 28, St. John's Wood Road, N.W.8. Rabbi Dr. I. I. Mattuck officiated. Relatives and others present included Mrs. Henry Dreyfus (widow), Maj.-Gen. Algernon Langhorne, C.B., D.S.O., M.C., Sir W. Alexander, K.B.E., M.P., Mr. T. Levy, M.P., Sir Percy Ashley, K.B.E., C.B., Rt. Hon. Lord Bicester, Mr. R. Boothby, M.P., Major A. N. Braithwaite, D.S.O., M.C., M.P.

SOCIETY NEWS

INSTITUTE OF THE PLASTICS INDUSTRY (Midland Section).—Friday, February 16, lecture meeting, commencing 6.30 p.m., at the James Watt Memorial Institute, Great Charles Street, Birmingham, 3, when a paper entitled "High Power Testing of Switchgear" will be read by H. C. Fox, Esq. (Messrs. George Ellison, Ltd.). Refreshments served from 6 p.m.

Friday, March 2, 1945. Luncheon meeting at the Imperial Hotel, Temple Street, Birmingham, 2, commencing 12.30 p.m. for lunch at 1 p.m. H. W. Graesser-Thomas, Esq., will give a short talk dealing with "Controls in War and Peace Time." Applications for tickets should be made direct to the hon. secretary forthwith.

Saturday, March 17, 1945. Dance at Botanical Gardens, Edgbaston, Birmingham, 15, from 3.30 to 8.30 p.m. Tickets 5s. 6d. each, which may be obtained from the hon. secretary, Mr. C. P. Hughes, care of Bakelite, Ltd., 1, Kinston Green Road, Olton, Birmingham, 17.

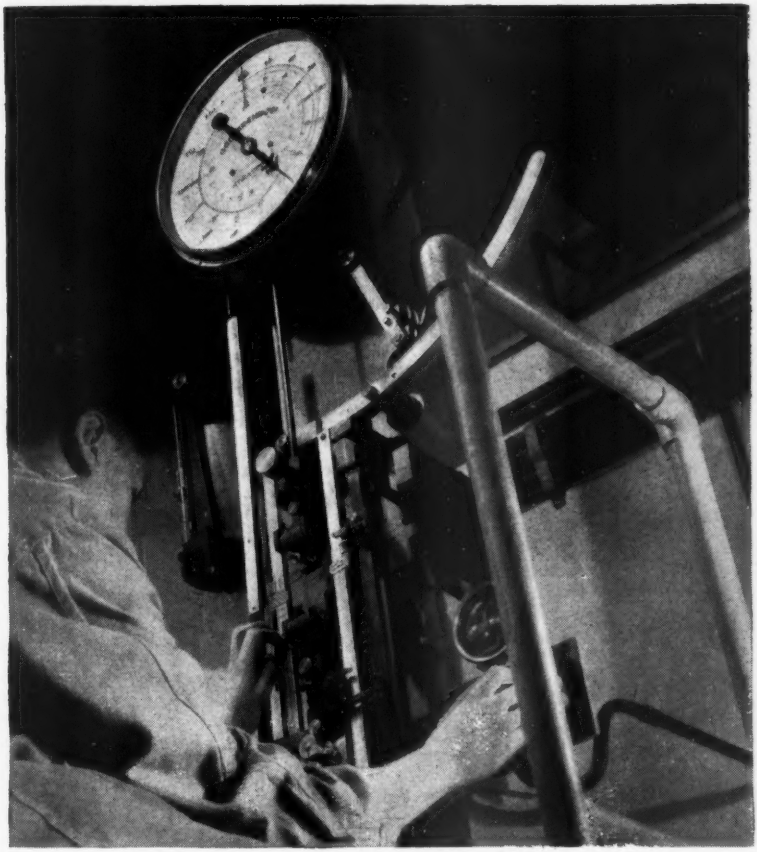
I.P.I. (SOUTHERN SECTION).—The annual dinner and dance of the Southern Section of the I.P.I. was held on Friday, January 26, 1945, at the Polygon Hotel, Southampton. Two hundred members and guests had a very enjoyable evening.

Speeches were made by Dr. Harry Barron, F.R.I.C. (Chairman of the Southern Section), Air Marshal Sir Leslie Gossage, K.C.B., C.V.O., D.S.O., M.C., The Mayor of Southampton, Alderman J. C. Dyas, M.C., and Mr. Craven-Ellis, M.P.

Thanks are due to the following firms for their co-operation:—Messrs. Birkbys, Ltd.; Messrs. Catalin, Ltd.; Messrs. De La Rue Plastics, Ltd.; Messrs. I.C.I., Ltd., (Plastics Division); Messrs. Erinoid, Ltd.

Plastic articles were auctioned for the "Spitfire Mitchell Memorial Fund." The total proceeds contributed to the fund amounted to about £100.

Wednesday, February 21, 1945. The next technical meeting of this section will take place at Southampton on this date, when Mr. H. Carl Martin, of the Bristol Aeroplane Co., Ltd., will give his paper on "Pulp Preform Moulding."



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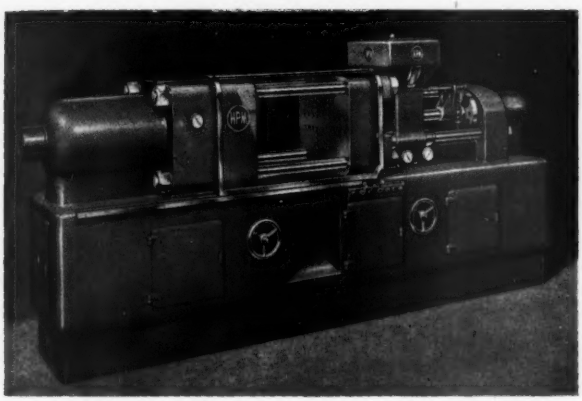


Fig. 1.—General view of the new, 16-oz. machine.

Modern Developments in Injection Moulding

Notes on a New 16-oz. Machine

An entirely new injection moulding machine of 16-oz. capacity is announced by The Hydraulic Press Mfg. Co., Mt. Gilead, Ohio, U.S.A., for whom A. C. Wickman, Ltd., Coventry, are sole agents and engineering representatives in Great Britain.

This machine, a self-contained unit illustrated in Fig. 1, will answer the ever-increasing need for larger capacity machines for production moulding of thermo-plastic components. It is "all hydraulic" in operation and incorporates many new features.

One of the main features of this machine, as with all H.P.M. injection moulding machines, is the hydraulic mould clamp. This consists of a double-acting ram, fitted with metallic piston rings, working in a smooth-bored steel cylinder. The main ram is equipped with an internal booster of a new and improved design.

The booster ram closes the clamp platen rapidly to within a fractional part of an inch of the total clamp stroke. At this predetermined position, hydraulic fluid under pressure is shifted to the large ram area.

This arrangement permits practically all of the clamp travel to be made by the use of the fast-closing booster ram. The forward stroke of the mould clamp ram is limited by an hydraulic by-pass arrangement which eliminates the need for stop collars on the tie rods. The return stroke is adjustable to any position within the limits of the clamp ram stroke, thus permitting the minimum mould clamp movement.

The die head is made as a one-piece solid-steel forging and is moved forward hydraulically. This arrangement permits automatic retraction of the mould from the nozzle tip which breaks the sprue. For easy access to the heating chamber the die head can be moved forward hydraulically until the chamber is clear. This arrangement

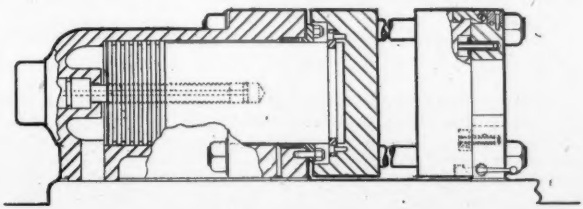


Fig. 2.—The hydraulic mould clamp unit.

permits the operator to inject plastic material into the atmosphere without entering the mould.

The stationary head consists of a U-shaped solid-steel plate acting as a stop for the movable die head. U-shaped opening permits unmolested clearance for easy removal of heating chamber or nozzle and easy access to nozzle contact bushing. The hydraulic-injection unit is equipped with a double-acting ram fitted with metallic piston rings working in a smooth-bored steel cylinder.

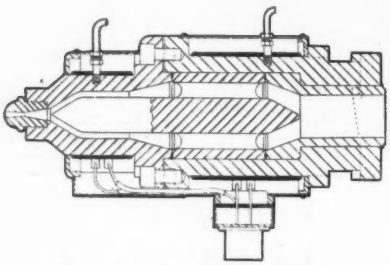


Fig. 3.—The new heating chamber.

The injection chamber is securely mounted to an adjustable steel cradle, which is held in accurate alignment on two tie rods. It is made adjustable in order to accommodate heating chambers of various lengths. All internal faces in contact with the plastic material are chromium plated. A new feature in the design of this chamber is the interrupted wedge locking device permitting the removal of the chamber by simply turning it through 60 degrees.

The forward movement of the injection plunger measures the amount of material to be fed into the heating chamber. The return movement of the injection plunger pushes material into the feed chute, the material dropping by gravity into the feed chamber. Sprues and gates can be fed direct into the feed chamber.

The machine can be operated by semi-automatic control or manually. For semi-automatic cycle, a simple multi-flex timer is provided for controlling the clamp and injection actions. The operator must start each cycle by moving clamp-operating lever. With manual operation it is possible to operate the clamp and injection units independently. Manual controls are provided for motor and heat on and off.

The actual heating chamber consists of two housings, front and rear, with removable plunge bushing. These bushings can be furnished with various bore diameters to accommodate plungers of corresponding diameters. The torpedo or spreader is clamped to the front chamber housing and is so arranged in order to facilitate removal of the torpedo without removing the chamber from the machine.

Nozzle tips, available with orifices of various sizes, can be quickly interchanged. The heating chamber is designed with two positive heating zones, which are separated by an insulating air gap, which makes it possible to maintain a differential of 160 degrees F. between the two heating zones. By maintaining a higher temperature at the rear of the chamber, the cooling time after the material has been injected into the die can be reduced, thus permitting a faster overall machine cycle. As the torpedo is also heated, the moulding material is heated from the inside as well as from the outside.

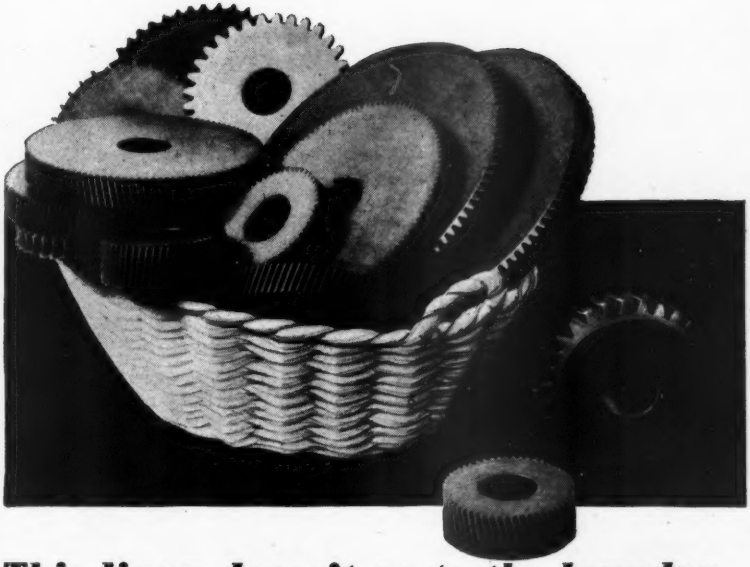
This two-way heating feature ensures faster plasticization. Suitable disconnecting plugs are provided for thermo couples and the easily replaceable heating bands. There are two indicating temperature controls for each heating zone. The temperature range has been increased to cater for the latest developments in thermo-plastic materials.

This new heating chamber is the direct result of a great amount of research and has been thoroughly tested in production service.

Perkin Medal Award

The American Society of Chemical Industry has awarded the Perkin Medal, one of the highest honours in world science, to Dr. E. K. Bolton, chemical director of E. I. Du Pont de Nemours. The award is made to oustanding workers in the field of industrial chemical research, Dr. Bolton having specialized in high molecular weight polymers; his work in the development of synthetic rubbers such as neoprene, which, although its production is by no means as great as Buna synthetic rubber, was one of the earliest to achieve success in the U.S.A. and Great Britain. His ability was also seen in his direction of the research carried out by the late Dr. Caruthers on nylon and other protein-like polymers.

The award of the Perkin Medal was established many years ago in honour of Sir William Perkin, the English chemist who discovered the world's first synthetic dyestuff.



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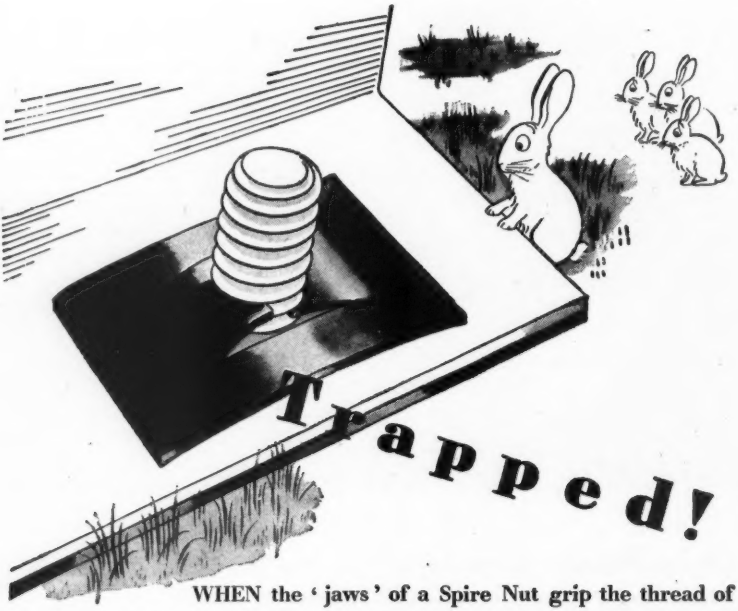

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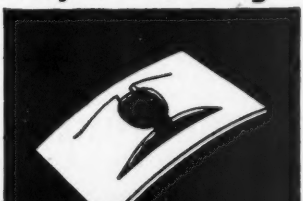

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3

Planned Mould Maintenance Service Aids Economical Production

Part X

By W. M. HALLIDAY

In continuation of the study of Injection Moulds for producing threaded components, to which subject the two preceding sections have been devoted, attention is now focussed upon a number of essentially preferable design and construction features capable of being readily embodied in more complex types of moulds arranged for fully automatic operation.

With this kind of complicated tool the thread-forming cores are located, unscrewed from the finished article, and subsequently returned correctly to proper position in readiness for the next moulding cycle, entirely by automatic and mechanical means.

The aim and purpose of such arrangements being to step-up production by eliminating idle machine time and wasteful manual operations, which assume very considerable importance in the case of multi-cavity moulds.

IN the particular consideration already afforded to injection moulds for producing mouldings with threads, either external or internal, as published in the December and January issues of this journal, attention was mainly devoted towards considering the numerous unsatisfactory design and construction features to be avoided; and the various preferred methods which may be employed. In all these instances the moulds have been distinguished by extreme simplicity of construction, number of component parts, and method of their operation.

It will be recalled that all such moulds dealt with have possessed at least one common characteristic, i.e., that the thread-forming cores especially have been operated manually, either by unscrewing same from the extracted finished moulding or withdrawn therefrom whilst the article remains in the movable portions of the mould cavity.

In all the instances so far given and illustrated the problems arising have been comparatively easy of solution by the designer or mould maintenance engineer by reason of the extremely simple design forms and mechanical construction of the moulds. But when the complexity of the mould is increased as by the introduction of automatic means of core operation, for instance, the problems are similarly multiplied, and the designer as well as the maintenance toolmaker will find himself confronted with additional difficulties, or, rather, possible sources of trouble.

Dangers of Over-simplification of Mould Designs

In passing, it is worth while noting that the tendency to simplify mould designs and constructions, which in itself is an admirable and desirable aim, may be overdone in respect of injection moulds, and unless very careful forethought is given to any projected design being developed, serious limitations in respect of either speed of production, smoothness of operation, or adequate length of working life may unwittingly arise.

It is true that, generally, moulds have to be produced with a very keen regard to costs which a client is willing to pay, a factor which very often is reflected in a tendency to push simplification too far. Small but not absolutely necessary refinements and innumerable provisions calculated to enhance the life and accuracy of the mould are apt to be neglected in such circumstances.

This policy admittedly ensures a tool initially inexpensive, but the little gains secured very often are more than absorbed in the early need for repairs, replacement of worn components, alterations or modifications to construction

revealed by only a short period under production conditions.

Whilst it is not suggested or indirectly implied that complicated mould constructions are good solely by reason of their complex character; indeed, intricacy for the sake of elaboration should always be avoided. It is urged that a mould of extremely simple design is one worthy of closer study with a view to effecting slight adaptations and minor improvements, which, if conducted, would certainly produce an increase in working reliability and production life, as well as a greater freedom from serious maintenance difficulties.

Putting this important point another way, it may be generally stated that a very simple mould design will usually be quite good for short batch production, or where the working life is likely to be of small or medium duration, but where the output is to be considerable, or of a precision nature, such constructions will have to be modified in many ways in order to facilitate better resistance to wear, ready means for renewing worn or damaged parts, and the retention of original accuracy.

Generally speaking, injection moulds for threaded articles do not come within the category of simple moulds, especially where the tool has to be of the multiple-impression type equipped for automatic core operation and location, linked up with the automatic cycle of controlled movements of the injection machine itself. Obviously, such moulds must tend toward mechanical intricacy and naturally entail a greater proneness to faults, possible breakages of vital components, and demand a closer and more regular inspection, test, and repair service from the maintenance engineer than their simpler-constructed prototypes.

Critical Examination of a Typical Automatic Thread Mould

It now remains to deal in a somewhat detailed manner with one or two typical examples of automatic mould constructions and their characteristic features, which have been chosen chiefly because they are representative of a very extensive class of mould, and also because they will afford excellent opportunities for indicating the numerous undesirable points which should be avoided, and the more preferable forms and methods which should be employed if maintenance attention is to be kept at a minimum.

These selected designs illustrate moulds for producing an internally threaded component, but the objections noted, and the suggested improved forms are equally applicable to cases where an externally threaded part has to be produced.

It is necessary to point out, however, that the suggested preferred design forms should only be regarded as general guiding instructions in overcoming or avoiding many of the more commonly encountered operational troubles, due to the obvious fact that rarely can two mould designs follow identical lines. Both of these illustrations of objectionable and desirable mould features will serve as a reliable guide to designer, toolmaker and maintenance engineer by indicating the broad measure which can be taken to avoid the occurrence of all sorts of trouble when once the mould is placed in production.

Turning, then, to the illustration shown at Fig. 1, this is a sectioned view of a practically complete four-cavity mould for producing a circular hollow cap component. This article has a threaded circular recess at one end, in order that the cap may be screwed on to another male-threaded portion of a mating member. It should be noticed that the mouth of this threaded recess is surrounded with a concentrically located hexagonal extension of short length. This point of the component design is here mentioned because at a later stage it will be seen that advantage is taken of the shape at this side of moulding to facilitate its retention in the cavity of the movable mould block whilst the thread cores are

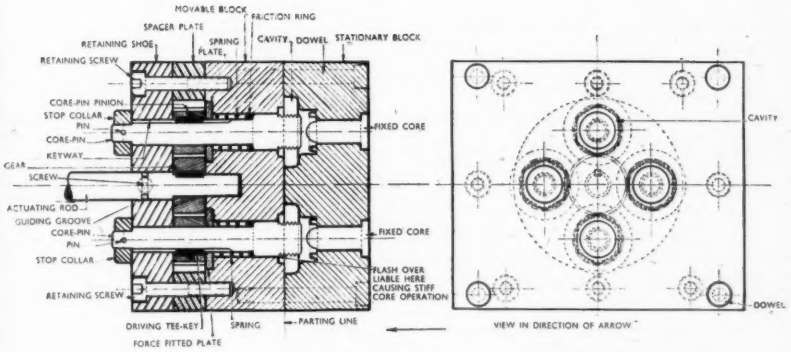

Fig. 1.

withdrawn prior to complete ejection of the finished product.

1. Disposition of Cavities

The first thing the writer wishes to stress in respect of this design is that of the location of the four cavities relative to the parting-line surface of blocks and their horizontal centre line. Here, in this instance, a satisfactory layout has been attained in that the cavities are approximately equally situated the same distance each side of the horizontal centre axis of mould blocks. Several very desirable advantages result from this balanced disposition.

The first advantage lies in the equalization of pressure upon the four dowels installed for aligning the respective blocks. Thus smoother operation is possible, and less side strain or binding action is likely to be thrown upon the dowels.

Secondly, an equal sealing land surrounding all the cavities is more easily secured than if the cavities were located excessively off the central axis.

Very often judicious selection of cavity location will very greatly assist in averting unequal side or lateral thrusts upon mould blocks and their attached plates, etc., dowels, cores, ejector rods and kindred mechanisms. This point will, of course, assume far more importance in those instances where the parting-line of a mould cannot be made to lie along a straight line, or where it must be inclined, or stepped.

Sometimes it is possible to locate the cavities upon an inclined parting-line surface in such a manner that the angle of inclination is in opposite directions for the top and bottom cavities each side of the horizontal axis, thus neutralizing angular lines of pull or thrust.

Incidentally, it is hoped to devote much further consideration to this point and the various useful methods which are and may be adopted to overcome the ill-effects of unsuitable cavity disposition and non-straight parting-line combinations in a succeeding section.

2. Assembly of Movable Block and Auxiliaries

It will be observed that the movable mould block provides the housings for the four core pins required for forming the threaded portion of moulded cap. In addition, all the extended mechanism is similarly contained within auxiliary plates attached to the rear face of the movable block, as shown and to be explained later.

For this latter purpose the movable block is provided with a stiff-sectioned plate or retaining shoe member, and two lengths of square cross-sectioned strip or spacer plates are interposed between the shoe and rear of movable block, in order to give the requisite spacing for the admis-

sion of the driving pinions and gears, by means of which the cores are rotated and positioned.

Unless some care is taken, maintenance and operating troubles may develop, because of the unsuitable methods or means adopted for securing these three members together. In this present illustrated design the retaining shoe plate is secured to the movable block by a number of socket head screws, these being passed into tapped holes machined in the movable block. These screws, eight in number, pass through clearance holes drilled through the two spacer plates, which latter are located top and bottom sides of block, as shown. No dowels are employed for aligning the retaining shoe plate and the two spacers to the mould block, and whilst it must be admitted that eight screws would give a very powerful lock or binding together of the three parts, nevertheless slight displacement of the shoe or spacer strips may be caused, say, by accidental dropping of the complete mould, or by too forcibly and too unequally tightening up the fastening screws holding the block assembly to the machine platen.

Should such an accidental alteration of the setting of these parts occur, numerous troubles might arise, some of which could develop to serious proportions, and a few of these may very usefully be recorded here:—

(a) As the retaining shoe in this type of construction is also used to afford end bearing to the core pins, any independent shifting out of correct position of the member will immediately tend to tighten the core pins within such bearing holes. At best this would produce much stiffer working, due to the increased sliding friction set up by the binding action on side of slightly misaligned hole, and at the worst complete inability to operate the cores could result, due to seizure. In any event, a very great additional strain would be imposed both upon the mould mechanism and the machine parts.

(b) Such action would also tend towards further slackening off of the screws, which in time would result in a slight opening between the joining faces of the three members. If the retaining screws are of very long length, the temperature of mould under working conditions may cause their elongation, sufficient to allow a slight opening along joint lines. Such openings speedily become the home for dirt and metallic or plastic particles, which prevent complete closure again unless attention is given by the maintenance engineer, who would have to strip those portions of the mould for cleaning, etc.

(c) Such features generally cause noisy and jerky action of the mould, which, whilst not serious, are certainly not conducive towards smoother and efficient production or freedom from wear and strain on mould parts.

Conditions such as the above often arise from quite normal and careful operation of the mould, and it must be remembered that such a mould will have to withstand very considerable clashing throughout a daily production run, as well as very substantial alterations of temperature. If a mould is allowed to run for lengthy periods at a gradually mounting temperature there will be a strong tendency for lubricant to be thinned so much that essential bearing points are no longer adequately fed, and if this drawback is coupled with slightly loosened plates which should be fixed to the mould block, additional tendency towards binding, wear, and seizure, is bound to result.

One very simple and inexpensive way for avoiding slackening off of the retaining screws would be to sink the head portion deeper into the recess at rear of retaining plate and to tap out the topmost portion of this recess so as to take a lock screw of the headless type, which would be screwed into place and locked down on to the head of the retaining screw when the latter had been properly locked down.

Another way in which help may be given towards better plate retention is not to drill clearance holes for the screws in either retaining plate of spaced strip. If standard holes are machined in these members, and the plain, unthreaded

shanks of the retaining screws carefully fitted so as to be a light press-in fit, they will then act as dowels to some extent. This provision should not, however, be employed as a substitute for properly fitted dowels.

Yet another useful point worthy of attention when fitting together such movable block auxiliary plates is to enlarge the top end of the tapped hole in the movable block for a short distance, say a depth equal to the diameter of screw, and to a diameter equal to that of the screw shank, so that when the screw is tightened down into place a portion of its plain shank actually passes down into the movable block. The utility of this dodge is that the strongest part of the screw shank is presented to the point where shearing or bending action is most likely to arise, i.e., at the joint line of the two parts. If this is not done and the screws are fitted in the ordinary manner as illustrated in Fig. 1, the weakest point of the screw is allowed to pass the joint face, as the area at bottom of the threaded portion is considerably less than that of the plain shank.

3. Attaching Movable Block Assembly to Machine Platen

Before leaving the matter of movable block assembly and methods of fixing or securing auxiliaries, plates, etc., it is necessary to mention a very connected subject. This concerns the provisions and methods adopted for securing the retaining plate to the machine platen. The illustration does not show this, however.

Wherever possible very long screws should be used for this purpose in order that they can pass through the platen slots, retaining plate, and spacer plate, and into tapped holes in the movable block. A very unreliable form of fastening would be obtained if the platen screws simply passed down into tapped holes in the rear of the retaining plate. By obtaining the first-mentioned kind of grip not only would a more rigid hold be secured, but also there would be less likelihood of trouble arising if the retaining screws were to slacken slightly as previously discussed.

It is nearly always advisable with such built-up mould assemblies to have at least a couple of dowels, or registering blocks for properly aligning the tool to the platen before clamping.

Finally, before such a plate assembly is passed for fixture to the machine platen a very careful check should be made to ensure the overall parallelism of the various plates. If a number of plates are used to build up the movable block and its auxiliaries, each of which is out of parallel by a small amount, say, .001 in., the resulting assembly may be appreciably lacking in parallelism, which will become the source of alignment troubles when the block is fastened to the machine platens.

4. Guidance for Thread-forming Cores

Perhaps the most undesirable and possible trouble-causing feature in connection with this design, shown in Fig. 1, is in respect of the lack of independent guiding means for the withdrawal of the cores from a finished moulding. These cores are rotated by means of gearing, this motion being arranged to commence after the mould blocks have been parted a short distance. As each core member revolves it is also unscrewed out of the moulded thread in the component, and it will be specially noted that this is the only means supplied in the construction for pitching the cores and moving them longitudinally.

Several highly unsatisfactory operational features result from this method, among which are to be noted the following:—

There will be a danger of final incorrect thread formation in the component due to wear as a result of the abrasive action of the core within the threads. The entire pressure needed to force out the core pin will have to be taken by the moulded threads.

Especially will such wear of moulded threads occur when the core pin has been in use for some time and the fit between the guide hole in the movable block has

worn slack. Rotation of the core in such condition is apt to produce a slight eccentric movement to the threaded end, which during unscrewing will tend to wear the finished moulded threads larger than correct size.

Particularly will these difficulties arise if for any reason the core pins are allowed to bind or to work stiffly within their guiding holes, because additional force will then be required to move them longitudinally, all of which will be directly transmitted to the moulded threads.

With a mould of this type the maintenance engineer will find it necessary regularly to test the core pins for freedom within the guide holes, and any signs of tightness or undue slackness would have to be corrected. Attention would also have to be paid to the questions of cleanliness and effective lubrication of such core pins throughout a production run.

5. Endwise Check for Core Movement

Yet another disadvantageous feature is to be found in the absence of a positive check to prevent core-pin movement towards the left at the instant of material injection into the mould cavity. When this takes place the end face of the core within the cavity will be subjected to a powerful lateral force tending to thrust backwards the core within the movable block.

In this present example a stiff compression spring is employed behind the shoulder portion of the core to return and hold the core in position for and during the actual injection of plastic material.

Where the threaded holes are of small diameter this end pressure set up during injection may not be very great, and probably a strong spring would suffice to retain the core in position. But in the case of large-diametered cores it will be found necessary to install some more positive check action to overcome this form of trouble.

Use of a spring in any event is likely to cause the maintenance engineer additional worry and attention because such parts very often speedily fatigue, or lose their temper, or break due to temperature or constant working of the mould. For these reasons springs should be avoided and positive mechanical checks provided wherever practicable.

At a later stage a very useful and efficient core-pin check action will be illustrated and described. This is of very simple design and is so arranged to function when the mould blocks are brought to the closed position, yet permitting free endwise travel of the core pins when mould blocks are slightly parted.

6. Positioning of the Core Pins

The core pins are positively positioned as to the amount of their projection into the mould cavity by means of a small collar, which is tightly secured to the slightly reduced extreme end portion of each core, as shown. This collar normally bears up against the left-hand end-face of the retaining shoe plate when the thread portion of the core is passed the correct distance within the mould cavity.

Whilst this ensures that the four cores are positively stopped so as to restrict their travel within the cavity, it is one, however, which often leads to variations in the depth of thread formed in the finished moulding for the following reasons:—

Because the stop collar is externally located on the mould, it the more readily becomes the target for injury by reason of contact with other articles when the mould is being stored, or handled apart from the machine. Or, again, should the mould be accidentally dropped or too forcibly placed on a bench the collars may be disturbed in their settings or have their right-hand end-faces bruised, all of which would tend to incorrect location of the cores within the block. Dirt, excess and thickened lubricant or powder particles, etc., may all tend to accumulate around these collars, and eventually to find lodgment between the collars and retaining shoe wall, which again would serve to locate the cores incorrectly.

Furthermore, with this design, if too considerable pressure were employed to return the cores to their moulding position there would be a danger of bending or even shearing the cross pins securing

the collars in place. Such action would result in the misplacing of the cores. The maintenance engineer would constantly have to be on the alert to detect such effects, otherwise large quantities of moulded articles could be produced having incorrect length of thread in their bores. Care would also have to be exercised to ensure that the mould was always handled with great care and maintained in very clean condition, whilst the faces of the stop collars would require frequent examination for the presence of burrs, accumulations of dirt, or any other additions likely to cause wrong positioning of the core pins.

7. Driving Pinions for Rotating the Core Pins

Here again in connection with these spur-toothed pinions and the method of their fitment to cores, etc., troubles are likely to arise in the case of moulds subjected to long runs and rapid production cycle. These pinions are each fitted so that the shank of the core pin is a free sliding fit within the bore, the latter being provided with a tee key, which also is capable of sliding within the parallel keyway along the side of the shank, as indicated. The tee key is tightly secured to the pinion by riveting. This allows the core to slide freely within the bore of the pinion and yet to have the same rotary motion which at times is imparted to the latter member. The shank of the core pin is extended sufficiently to secure a bearing in the bored hole in the retaining shoe at other side of pinion.

Very often these pinions have to be of small diameter and limited length, hence it is not always possible to install a sufficiently ample key able to withstand prolonged life without suffering undue wear. For this reason it will be advisable to harden such key, and to attach it to the pinion or core shank in such a manner as will permit of easy and quick removal for replacement purposes. Where the mould is large and heavy load is likely to be imposed on the driving keys, it may be found more satisfactory to employ splining of both pinion bore and the core pin shank. This allows a very strong connection between pinion and its shaft, and, moreover, there is no question of feather keys working loose. In the further illustration showing improved features to the type of mould shown in Fig. 1, it will be observed that two identical keys are used for taking the drive from pinions. In this manner additional surface contact is obtained.

Another very undesirable feature deserving attention from the designer and mould engineer relates to the keywaying of the core pin shank. Wear will not only occur along the sides of the driving key within the pinion, but also along the sides of the parallel keyway. Should this develop to an excessive degree it may mean the provision of a completely new core pin. This would undoubtedly prove an expensive matter, as it would involve withdrawing the mould from production for a considerable period. Especially would this be the case if several cores had to be thus replaced in a multiple impression mould.

A similarly costly core pin replacement would be necessary if the thread-forming end suffered damage or wear. As will be explained and illustrated later, it is possible to employ a very simple design, which obviates both these troubles and renders core-renewing operations very inexpensive in contrast to the above-mentioned requirements.

8. The Actuating Rod

Some trouble may arise in regard to the methods adopted for fitting this rod within the retaining shoe and the movable block. As will be seen, this rod is reduced at one end, and the small driving gear wheel fitted and keyed up against the shoulder thus provided. The reduced shank extends beyond the side of gear sufficiently to form a bearing within the hole provided in the movable block.

The rod also bears within the plain hole in the retaining shoe. No means are provided in either case for taking up wear which is likely to develop within these bearings; as a result of this, stiffened and jerky motion is apt to occur, which will

impose additional strain and weight upon the machine as well as operation of the mould.

Another undesirable feature relates to the method employed for preventing the actuating rod from endwise movement within the shoe plate. The bearing at this point is provided with a shallow annular groove around the shaft, into which is fitted easily the short pip end of a check screw located in a tapped hole in the shoe plate. This permits the rod to be rotated, but prevents its endwise movement. The sides of this groove and the screw pip extension will both be subject to considerable wear, and the screw will probably require very frequent replacement if smooth running is to be assured.

Although not here illustrated, the actuating rod is operated automatically by means of a rack and pinion drive, the former member being secured either to the top face of the stationary mould block or the fixed machine platen, as may be convenient. This portion of the design is here omitted because it follows normal tool-making practice, and if carefully and securely installed need give little trouble to the maintenance engineer.

In connection with this form of drive, however, the writer would like to mention that he has often found it beneficial not to fix the driving pinion meshing with this rack positively to the end of the actuating rod, but instead to incorporate some simple form of frictional drive between these two members. This will often be found advisable in order to allow the drive to the actuating rod and core pins to slip when the latter reach their proper position in readiness for the injection stage, or when some obstruction to their free working is encountered. Such a frictional drive could consist of two spring-loaded rings embedded within the driving gear and a shoulder of the actuating rod, which would thus allow slippage of drive when an overload was met.

The present writer has also on occasion employed with success a chain drive to the actuating rod from the rack pinion. The advantages to be derived from this application are the elimination of intermediate gears to bridge intervening spaces necessitated by the position of the cores, and also allows the operating rack to be affixed with greater choice of location on the platens, machine slides or stationary block.

Yet another point well worthy of noting and adoption in all such gearing connections from actuating rod to cores, is to employ spirally toothed members rather than spur forms. By reason of the sliding contact of the former, as against the purely rolling action of the latter, gears, a much smoother operation will result. In addition, where the overall dimensions of the mould restrict the diameter and length of such pinions and gear wheels, use of helical forms enables greater tooth length and consequent strength to be secured than would be the case with spur-toothed gears.

9. Miscellaneous Disadvantageous Features

Before leaving consideration of this design shown in Fig. 1, several other minor points of unsatisfactory construction call for attention and interest. These are as follow:—

(A) Return of the core pins is accomplished by a compression spring action. In order to prevent this member from unwinding itself or binding, a special plate or ring has to be press fitted into a counter-bored recess at the rear end of the hole in the movable block. This ring is needed in order to present a stationary face at both ends of the spring. A friction ring is also interposed at the other end of the spring as shown. This provision entails additional machining operations on the movable block.

(B) It will also be observed that the termination of the threads on the core pin coincide with the extreme left-hand end face of the hexagonal extension of the moulding. In operation a flash over of material will probably take place at this point, as a thin sliver of plastic material will be forced past the run-out of the thread on cores at each injection. There will be a tendency for such flash to pass into the parallel bearing hole in

which the core revolves and slides, and may produce a binding effect upon that member. In the case of a mould having only one or two cavities this may not prove serious, but where a large number of impressions are present the accumulated stiffening effects may be very considerable.

The maintenance engineer would have to devote very frequent and careful attention for the detection of this form of trouble in its early stages, and, of course, remedial action would require the removal of the mould from machine, and the stripping of the cores for proper cleaning. In the ensuing discussion on

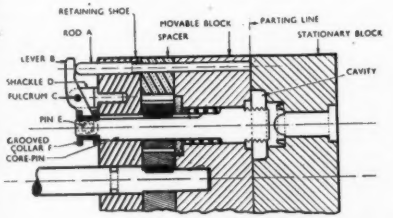

Fig. 2.

a preferred design of mould for these caps suggestions will be made whereby this difficulty can be easily overcome.

(C) This question of flashing must be very carefully watched on all injection moulds, and particularly on designs similar to the one here described. If jointings of plates, strips, pins; etc., are located too near a cavity there will always be the danger of excess material being forced into tiny crevices to find permanent lodgment there and possible stiffened working of the various members

(D) Since the bearings for the core pins and the actuating rod, etc., are not bushed but simply machined into the mould block and its auxiliaries, in the interests of reduced frictional contact and lesser wear, it will be advisable to make up these parts from different materials, preferably those possessing little affinity with each other. This is not always possible, hence another reason should be noted for the use of special liners to all bearings.

10. Automatic Interlock and Check for Core Pins

As will already have been appreciated, one of the chief trouble-causing drawbacks appertaining to the construction described in Fig. 1, is the lack of a positive stop to prevent each core pin from being forced backwards at the time the incoming plastic material impinges on the end faces of core within the mould cavity.

In Fig. 2 is illustrated an exceedingly simple yet most effective modification to the existing design which affords a positive locking action to the core rods during the moment of injection.

This useful adaptation is secured in the following manner. A small shouldered rod as at A is furnished so as to slide freely within the stepped hole horizontally located in the movable mould block, spacer, and retaining shoe plate as shown. This rod is made up of sufficient length so that one end thereof bears against the parting-line face of the stationary mould block when both blocks are in closed position, and to project outwards at its other end beyond the side face of the retaining shoe sufficiently to bear against the lipped portion of the swivelling lever B.

This latter member is made an easy swivelling fit upon the fulcrum pin C passing through the slotted shackle D. The shackle in turn is screwed by means of a threaded stalk into a suitably tapped hole in the end face of the retaining shoe.

Lever B is extended downwards below the centre of the fulcrum pin the required distance so as to bridge the gap left between the shackle and the centre of the grooved collar F pinned securely to the reduced and shouldered end of each core pin shank.

Fitting so as to run freely within the annular groove around the collar F is the pin E, which is secured to the lower end of the lever B in such a position as to bring centre of pin in same line as that of the core pin. The illustration shows only one core pin fitted in this manner for the sake of clearness, although all the cores would normally be so

equipped. With this mechanism, as illustrated, the core pin is in its proper position for moulding.

In this position it will be observed that the stepped rod A is lightly in contact at its rounded end with the top of lever B, whilst its other end bears against the parting-line face of the stationary block.

In this manner it is clearly impossible for the core rod to be moved backwards towards the *left* until the rod A is free to slide within the movable block towards the *right*, a movement permitted only when the mould blocks are parted. When this latter takes place the core withdrawing mechanism may then be operated and rotation of each core performed for unscrewing same from the finished moulding, in the same manner as described in reference to Fig. 1.

For the return motion after a finished part has been ejected the compression spring serves to push back the core pins whilst the mould blocks are still open. But the arrangement possesses certain safety features in that once the two mould blocks are brought into their closed position again, the core pin will be operated by means of pin A to bring it into its correct endwise position again. Thus should the compression spring weaken, or fracture altogether, no harm would be done to the mechanism as the return to the cores is entirely self-acting following on the ordinary opening and closing of the mould blocks.

This will be found a very reliable and, indeed, almost foolproof construction which in no way interferes with the ordinary smooth working of the moulds. Should some obscure cause develop to prevent the core pins from being returned completely to their injecting position, this will be at once revealed and indicated to the observant operator by reason of the fact that rod A will prevent the mould blocks being completely closed.

Incidentally the writer proposes at a later stage in a separate succeeding article to give some detailed attention to the study of several useful interlocking and safety devices which can be effectively applied for the retention or checking of cores, ejectors, and slides, etc. Such means, where incorporated, very often become the means of protecting the mould mechanism against damage or serious wear due to unskilled use by the operator, and constitute admirable safeguards against foolish handling and careless operation. Their introduction can often be a very great assistance to the maintenance engineer,

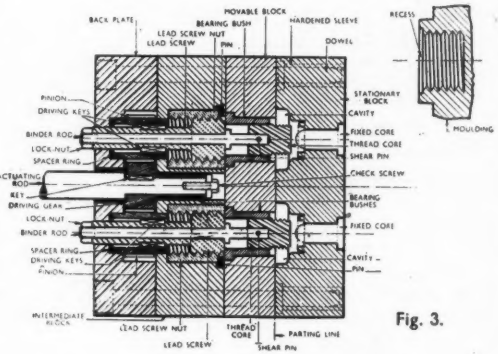

Fig. 3.

and designers are urged to give some attention to the questions of interlocking and positive checking, and safety when evolving mould designs. Too often such developments are regarded as expensive and unnecessary adjuncts whose functions should and can be just as effectively covered by a well-trained intelligent operator. But, unfortunately, these latter are few and far between, and even they are prone to moments of forgetfulness, hence the need for some purely mechanical contrivances which can function regardless of the vagaries of human memory or foresight.

The Preferred Mould Construction

Fig. 3 illustrates a sectioned view of a similar type of injection mould for producing the same cap moulding, but which

incorporates many considerably improved design, construction, and operating features, which in actual use will very greatly promote better running, long working life, and freedom from the numerous snags and difficulties noted in connection with the construction in Fig. 1, which are now considered as follows:—

11. Thread Cores

Dealing first with these important steel thread-forming core members, it should be noticed that they are made extremely short in length, comprising a short, plain cylindrical portion immediately beyond the threaded part. This plain diameter is made a free sliding fit within a liner fitted to the guide hole in the movable block. Several reasons underlie the making of these cores of such short length, chiefly to economize of material, machining time, and replacement costs, as, obviously, a piece of such a size and simple form will prove much cheaper to manufacture than the solid long cores employed in the previous construction. In actual fact, the savings in expensive alloy steel used for the manufacture of such cores in the case of a muitiple-impression tool were found to be very substantial, because not only had the initial purchase price of the material to be considered, but also the prolonged and costly heat treatment afforded to same after machining it to sizes.

As will also be seen the guide holes in the movable block are made large enough to receive specially hardened and shouldered bushes or liners. The opposite side of block to the parting-line is counter-bored, as shown, into which recess the head of the liner is situated. The shank of the bush is made a very tight press fit within the hole in block.

Not only will use of such bushes enable the initial degree of close fit between core and its guide hole to be maintained, or restored by renewing the bush if wear has occurred, important considerations for the maintenance engineer, by the way, but often the original machining and finishing to size of the mould blocks will be facilitated. Where mould blocks of intricate shape, or very large overall dimensions, have to be dealt with, setting-up difficulties may be encountered by the grinder or polisher in finishing off holes to correct sizes. The simple expedient of using liners avoids these troubles.

As a smaller matter of interest in regard to this particular improved design form, it will be observed that the guide hole in the movable block in which this hardened bush resides is made the same diameter as the distance across the corners of the hexagonal extension of the cap moulding. Further, the bush shank is made long enough so as to be finished off exactly flush with the bottom of hexagonal recess portion of cavity. The bush thus serves for stopping the cavity at this point for correct length, and also ensures that any slight flash formed at the junction line lies at right angles to the endface of the finished moulding, thereby being much easier to finish off than would be the case if the flash were along the same plane as end of component.

12. Movable Mould Block Assembly

Instead of the narrow rectangular spacer strips introduced top and bottom between the movable block and shoe plate, as indicated in Fig. 1, a complete plate, having the same overall dimensions as that of the movable block itself is employed, and indicated in Fig. 2 by the intermediate block. This improvement is required and worth while for several reasons, chief of which the following may be noted.

(a) By its use a much stiffer and rigid assembly is made possible, which, in turn, is bound materially to assist towards reducing possible sources of spring, distortion, and error in the completely assembled movable block set-up. By reducing such possibilities the risks of seizures of dowels, rods, core pins, etc., will be appreciably lessened, and wear obviated.

(b) The block is also utilized for housing the important master lead-screw guide

nut and the actuating rod, total enclosure being afforded to all these members, thereby excluding dust, moisture and other deleterious influences.

(c) Such total enclosure of all the essential mechanism not only prevents dirt from lodging thereupon, but also ensures that no unauthorized tampering and consequent damage is done to the mechanism by the careless operator.

This latter point is one, by the way, which often receives scant attention from the designer. One often comes across moulds having quite intricate mechanical arrangements, all or most of which is quite open and accessible from the outside of the mould, and thus present easy admission for dirt, contact with metallic articles, or the operators' fingers. Many instances could be given of mould troubles arising from the inquisitiveness or carelessness of some user in handling such exposed mechanisms. Where they can be totally and safely enclosed within a block or built-up space such risks are to a large extent avoided.

As in the previous example shown in Fig. 1, a stiff sectioned back plate or shoe is attached to the rear face of the intermediate block. All three plates or blocks should match up on their outside dimensions. The back plate is used for housing the necessary gearing for driving the core shafts.

It will also be noticed that the main mould block dowels are of very long length; in fact, almost equal to the overall width of the four blocks. The head portion of the dowel is located in the back plate, and each dowel, it will be seen, thus passes through, first, the back plate, then the intermediate block, and the movable block, thence into the fixed block. In this way all three pieces of the composite movable member are effectively dowelled and aligned in addition to the screws. The clamping screws (not here shown) are retained against accidental slackening in the manner already explained in dealing with the design of the first mould.

With this method of securing together the various parts there should be little danger of jointing faces coming slightly apart or warpage occurring.

13. Master Lead-screw Guidance for Core Travel

As before mentioned, the design in Fig. 1 relies upon the plastic-formed threads of the finished moulding for moving the core in an endwise direction when the latter is rotated, a method which, in practice, results in some very unsatisfactory features. Threads of the component may be damaged, especially at the feather-edge run-out at mouth of bore. This fine edge may be broken and left very jagged because of its weakness and inability to force out the core pin the extra distance to clear the end of the thread. In the case of precision threads, such a trouble must be avoided, and so, for a variety of reasons, it is advisable that the core pin be independently guided out of the moulded threads, so that the latter are left undamaged.

This is accomplished by providing a master lead-screw which can be freely operated within the phosphor-bronze nut which is housed in the intermediate block, as shown. The lead-screw, of course, would be of carefully selected steel, very accurately machined and heat treated, with ground threads for preference. The lead-screw nut is fixed tightly to prevent rotation within the suitably bored hole in the block. A small pin made to extend into a shallow slot is used to restrict turning of the nut within its hole. As shown, the hole for the nut does not extend through the intermediate block; instead a small step portion is left at the left-hand side, against which the end of the nut rests. At its other end the lead-screw nut lies flush against the endface of the bush in the movable block. When the two blocks are thus secured together there is no danger of either nut or bush becoming disturbed in an endwise direction.

The threads on the lead-screw itself are made on a considerably larger diameter than that of the actual core threads. This

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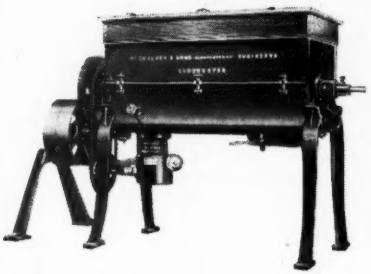

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is important because it enables a greater surface area to be utilized over which the load can be distributed, thus imparting more freedom from wear and longer working life with retention of original accuracy. If the lead screws were to be made of very small diameter it would not be nearly so effective nor reliable for the above reason.

The master lead screw is provided with a long parallel shank section, and the whole piece bored out dead concentrically to take the binder rod, which latter is passed within the lead screw and locked up against the inner shoulder by the lock-nut on outside end of lead screw shank. This binder rod should be very tightly clamped up in position so as to act in unison with the lead screw in all its movements.

At its inner end the thread-forming core normally working within the movable block is connected up to a short parallel extension of the binder rod by means of a small-diameter cross pin passed through both members. This pin not only serves to secure the thread core piece to the master lead screw, but also functions as a safety device in the shape of a shear-pin, which, of course, is made small enough to shear off completely should the load imposed on cores during extraction from a finished moulding become too great. Such a shear-pin could well be of softer material and probably the mould engineer would require to make one or two trials before the correct strength of diameter was obtained, and the little trouble entailed in arranging this provision would certainly be found of considerable benefit when the mould was placed in service and exposed to the severe working conditions and treatment.

Positive stop action is provided for the positioning of the thread-forming core member within the mould cavity by making the right-hand end of the master lead screw to bear dead up against the end face of the lining bush within the movable block when core projects the correct distance into cavity. This internal location of the stop face greatly assists in preventing wrongful location due to presence of dirt, thickened lubricant, etc., as was noted in association with the first mould design.

14. Gearing for Operating Lead and Core Screws

In comparison with the undesirable features observed as arising from the design previously considered, the method of construction here suggested in Fig. 3 will be found far more satisfactory and definitely the source of much less operating trouble for the maintenance engineer.

The bore of the drive pinions on each lead screw shank is made slightly larger than the diameter of the latter so as to permit it being a very free fit thereon. The writer suggests an additional amount over the shank diameter of about .006 to .008 in. The surface of the bore should be very highly polished before the final assembly in place, thus lessening frictional contact.

Two parallel keyways are machined diametrically opposite and passing clean through the pinion bores, and two feather keys are located in seatings machined in the sides of the lead screw shanks as shown. Where the diameter of the shank allows it, these keys might usefully be fastened down in their seatings by small vee-head screws. This means would assist in preventing the keys from working loose in their sockets and so causing additional backlash in the drive.

At each side of the pinion a short cylindrical extension is provided, machined up very accurately and concentric with the bore, of course. These extensions are then made a nice running fit within the bore hole in the left-hand side of the intermediate block at one side of the pinion, and the recess in the back-plate at the other side. This latter plate, by the way, is also enlarged in the recessed portion in order to provide working clearance for the toothed surface of the pinion.

In this manner the pinions are thus afforded adequate bearing surface within the movable block assembly, irrespective of that given by the parallel shank portion of master lead screw, which, it will

be recalled, is a free fit. The advantage to be derived from this method of fitment is that any off-centre thrust imparted to the pinions by reason of their engagement with the driving gear on the actuating rod, will not be conveyed to the shank of the lead screws as is the case with the arrangement in Fig. 1. Thus the lead screw and its shank portion will be free to move in an endwise direction with entire freedom regardless of the radial pressure which might arise from the gearing of the pinion. In this manner there should be practically no wear or bending action occurring on the lead screw shank or pinion bore.

A further useful point is that of the introduction of the spacing ring interposed between the left-hand end face of the pinion and the bottom face of the bearing in back-plate. In thickness this ring, which acts as a thrust washer, should be sufficient to take up any unnecessary end play of the pinion yet permitting proper working clearance. The material of the ring should preferably be of some well-known anti-friction substance.

Should undue end play develop between the pinions and the sides of their bearing holes, noisy and jerky operation may result, coupled with more rapid wear.

15. The Actuating Rod

Here again it must be remembered that often heavy loads will be placed upon this mould member, especially where a large number of thread cores have to be simultaneously operated. This will render the rod bearings liable to considerable wear. To prevent this wear each bearing point is provided with easily renewable hardened and ground bushings as shown. Use of such bushings will be of much assistance to the maintenance engineer who is charged with keeping the moulds in accurate and workable condition.

Where bearings of the non-bushed kind are used, as in Fig. 1, should excessive wear of the bearing holes occur, it will be necessary for the maintenance toolmaker to remove the back plate and intermediate block, and movable block, in order to set up each member in the lathe or jig-boring machine, to enlarge the worn hole sufficient to receive a bush. In performing this setting-up task it will be exceedingly difficult to locate with confidence the exact centre of the worn hole, with the result that when the holes have been enlarged and bushed some misalignment with existing holes in other block members is present. This danger is, of course, entirely avoided by the use of bushings at these points from the very beginning of the mould's life, as all the wear will take place on the bore only of the bushes, which can then readily be removed and new parts fitted in their place with an absolute guarantee that true centre has not been lost, so that from the manufacturing point of view the wider application of such simple time-saving measures seems amply required.

It will also be seen that the actuating rod is more effectively positioned and held against endwise movement than is the case with its counterpart in the design shown in Fig. 1. Instead of a pip-headed screw engaging within a circular groove in rod, a screw and washer are attached to the extreme end face after this latter has been carefully adjusted to allow a free working clearance over the end of the bearing bush.

16. Positioning of the Thread-forming Core

The illustration also shows a simple way in which the danger of flash over of plastic material at the thread run out on the core can be avoided, or, at any rate, largely negatived. This is secured by extending the plain diametered portion of the core shank sufficient to project a slight amount into the mould cavity as indicated. This plain shank diameter should also be made slightly larger than that of the finished thread portion of the core, an increase of some .010 in. should be adequate. The effects produced on the finished moulded article by this method are illustrated in the small inset view at the upper right-hand corner of Fig. 3. From this illustration of a section of the finished part it will be noticed that a very short depth of recess is provided at

the mouth of the moulding whose outside diameter is greater than tops of thread. The feather-edge run-out of the threads thus finishes normally a little distance from the end face of the moulding, whilst the short paralleled portion actually projected within the mould cavity serves more effectively to seal off any tendency of the flowing plastic material to force a way past end of threads and into the plain bearing hole of the core.

Before leaving this question of thread-forming cores, it should also be mentioned that the use of short component cores of the type just described affords the mould designer and engineer great convenience in another direction. Very often great savings can be effected in mould costs if provision for making them adjustable within certain limits can be incorporated. Where a number of similar-shaped articles have to be moulded with different diameters or styles of thread, the designer will often be able to utilize a design of the kind just discussed, by arranging for a number of different core members to be made interchangeable on the end of the binder rod. Thus adjustment of the mould required for producing a moulded component having a different thread size or form would only entail removal of the unsuitable core member and the fixing in its place of the proper thread core. The core mechanism required for withdrawal, etc., would function in the same manner, of course, and little or no alteration would be entailed.

17. Lubrication and Cleanliness

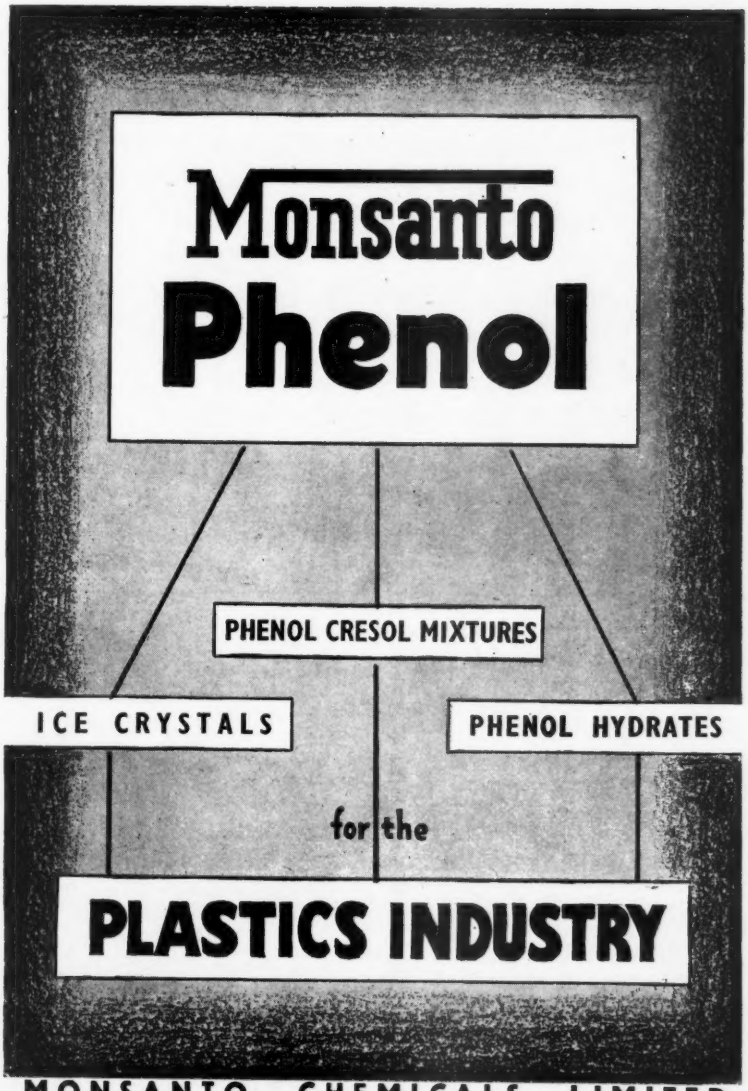
On all the foregoing designs no provision is shown for lubricating the various mechanisms. It goes without saying almost that the mould engineer should make effective provision for ensuring that ample supplies of the correct kind of lubricant are applied to the respective parts of mould. Because of the temperature rise associated with injection moulds, and the very rapid speed of production as well as the generally more complicated forms of construction employed than in moulds for the compression process, adequate lubrication is essential.

Referring again to the design illustrated in Fig. 3, the circular recessed portion in the right-hand face of the back plate normally housing and enclosing the gears could very well be partially filled with a suitable grease, or lubricant of the colloidal-graphite base, which latter would the better withstand moisture and heat effects. Such a method of lubrication, obviously, is impossible with the exposed gearing shown in Fig. 1.

One very important matter requiring careful planning is the provision of adequate oil-feed to the master lead screw and its nut. Open-ended oil pipes or channels commencing from the exterior surfaces of the mould would prove unsuitable, as dirt and other harmful substances might find lodgment within the tube, so blocking off any supply of oil. Such feeder pipes should be fitted with automatically closing screwed nipples of the "Enot" type preferably, which have to be supplied with oil by means of a pressure gun placed over the nipple.

The moulds should also be dismantled every two or three weeks at the most if engaged on continuous production, in order to give all the internal mechanism a thorough inspection and cleansing and regreasing. It will be found that considerable amounts of corrosion of the internal surfaces occur due to heat and moisture condensation, and if this is allowed to remain for long periods will it produce roughened bearing surfaces, or flanks of master screw threads especially, which will lead to increased friction and greater wear. But with regular inspection at specified frequent intervals in the manner suggested very reliable and satisfactory service should be easily possible.

In the succeeding section the author proposes to deal with the important questions of safety and interlocking mechanisms as applied to injection mould constructions in particular, as the introduction of such safeguarding devices very greatly assists in preserving moulds in good working condition, and definitely makes for reduced maintenance activity in their upkeep.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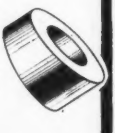

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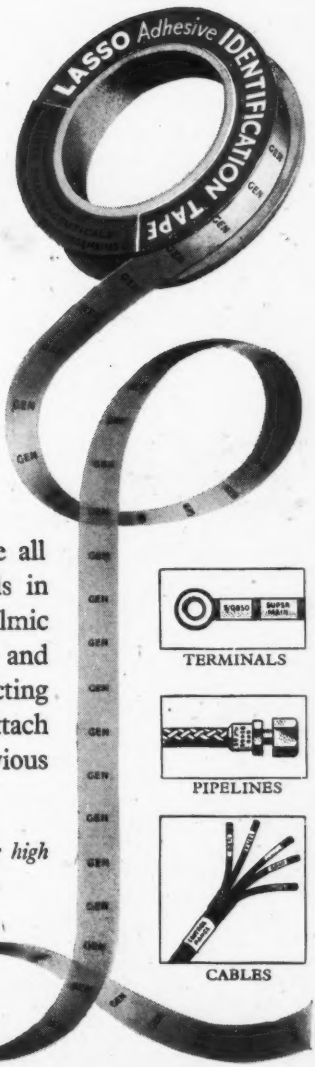

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